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Reduction of Total Toxic Organic Discharges and VOC (Volatile Organic Compounds) Emissions from Paint Stripping Operations Using Plastic Media Blasting

Acurex Corp., Mountain View, CA

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16. ABSTRACT

The US. Army Toxic and Haza[illegible] Materials Agency and the U.S. EPA Water Engineering Research Laboratory cooperated to investigate the feasibility of Plastic Media Blasting (PMB) as a paint removal technique for aluminum military shelters. The PMB process was compared in field tests with sandblasting and with chemical stripping to determine relative cost, effectiveness, efficiency, and environmental consequence. The PMB process was judged superior to the chemical stripping process and marginally better than sandblasting based upon the evaluation criteria.

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FOREWORD

The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water systems. Under a mandate of national environmental laws, the agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. The Clean Water Act, the Safe Drinking Water Act, and the Toxics Substances Control Act are three of the major congressional laws that provide the framework for restoring and maintaining the integrity of our Nation's water, for preserving and enhancing the water we drink, and for protecting the environment from toxic substances. These laws direct the EPA to perform research to define our environmental problems, measure the impacts, and search for solutions.

The Water Engineering Research Laboratory is that component of EPA's Research and Development program concerned with preventing, treating, and managing municipal and industrial wastewater discharges; establishing practices to control and remove contaminants from drinking water and to prevent its deterioration during storage and distribution; and assessing the nature and controllability of releases of toxic substances to the air, water, and land from manufacturing processes and subsequent product uses. This publication is one of the products of that research and provides a vital communication link between the researcher and the user community.

This particular study investigates the environmental and technical feasibility of using plastic media blasting as an alternative for solvent stripping and/or sand blasting to remove paint from aluminum substrates. This study was funded by the U. S. Army Toxic and Hazardous Materials Agency and was conducted cooperatively with the U. S. Army, the U. S. Air Force and the National Institute of Occupational Safety and Health , thus optimizing resources and expertise between government agencies. For further information on this topic, please contact the Manufacturing and Service Industries Branch of the EPA Water Engineering Research Laboratory.

Francis T. Mayo, Director
Water Engineering Research Laboratory

ABSTRACT

PLASTIC MEDIA BLASTING

The purpose of this project was to compare Plastic Media Blasting (PMB) with the two most common forms of paint removal, chemical stripping and sandblasting, specifically for military communication shelters. All three processes were compared with respect to the environmental and economic impacts of their use. The efficiency of each method was also assessed. The economic issues investigated were the costs of the material and labor, time required to depaint an item, and the cost of waste treatment and disposal. The relative hazardous nature of each of the waste generated by the three methods was also assessed. This report was submitted in fulfillment of Contract No. 68-02-3993 by Acurex Corporation under the sponsorship of the U. S. Environmental Protection Agency. This report covers a period from January, 1985 to January, 1987, and work was completed as of October, 1986.

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SECTION 1

INTRODUCTION

The following report presents the results of work conducted for the U.S. Environmental Protection Agency (EPA) under Contract Number 68-02-3993, WA-16. The project was funded by the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) through EPA and represents an interdepartmental study. The work was performed under the auspices of the Water Engineering Research Laboratory Manufacturing and Service Industries Branch of the Office of Research and Development, Cincinnati, Ohio.

This project was initiated and conducted by EPA for the U.S. Army, specifically for the purpose of determining if Plastic Media Blasting (PMB) can be a viable substitute for the Army's present paint stripping processes. The benefits of these results, however, go far beyond the U.S. Army requirements by presenting to the U.S. industrial community a new depainting process that is relatively pollution free and highly efficient.

1.1 BACKGROUND

EPA has promulgated an effluent regulation governing the discharge of waste from metal finishing processes (Ref.1). The regulation lists some 110 organic compounds that are included in total toxic organics (TTO) (1). This

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1. TTO compounds are those compounds listed in Title 40 of the Code of Federal Regulations 433 as amended by Vol. 49 of the Federal Register, September 4, 1984, p. 34823.

regulation (Ref. 1) sets limits on the TTO discharge. Paint removal is a major process in the metal finishing industry. The removal of old paint from metal and composite structures has frequently required, until recently, the use of organic chemical strippers or sandblasting. The organic strippers typically contain up to 75 percent organic solvents such as methylene chloride and phenols, and can add to the TTO discharge levels from the total facility. They can also produce air volatile organic compounds (VOC) pollutants and hazardous waste discharges. The waste products from chemical stripping must be treated or disposed of as a hazardous waste in accordance with federal and state regulations.

Sandblasting is the other major process used to remove paint. The aggressiveness of the sand precludes its use on many substrates. Sand particles are relatively hard (approximately 7 on the Mohs scale). The density of the sand particles (approximately 3.5 gm/cm^3) requires a high air pressure to blast. The combination of these factors can cause warpage and/or erosion of the substrate from friction heating thus limiting its use. In addition, large volumes of waste material (sand contaminated with paint dust) are generated. In at least one state (eg. California) the sandblasting waste is classified as a "special waste". The special waste classification is a subcategory of hazardous waste which can allow for exemptions from hazardous waste disposal requirements under certain conditions. Both chemical stripping and sandblasting generate undesirable residues that must be disposed of in an environmentally acceptable manner. Therefore, in the past few years there has been an increasing effort to develop and demonstrate

suitable depainting processes. These efforts have resulted in the development of plastic media blasting (PMB).

The use of plastic as a blasting media is a revolutionary paint stripping procedure that is currently being evaluated by a number of companies and governmental agencies. The technology also has benefits from an environmental perspective. It generates a lower volume of solid waste than sandblasting, and has the potential to significantly reduce the VOC emissions, water (TTO) discharges, and hazardous waste that currently result from chemical stripping. The bead blasting process, similar to sandblasting, is totally dry. Only the dry residual paint and plastic dust require disposal and at a fraction of the volume of chemical stripping and sandblasting.

1.2 PROJECT OBJECTIVE AND APPROACH

The purpose of this project was to conduct an independent evaluation of the PMB process for use on selected military equipment, and to compare PMB with the conventional depainting technologies of chemical stripping and sandblasting.

The basis on which all three processes were evaluated were the economics, the environmental impacts, and the efficiency of each depainting method. Economic issues investigated were the costs of the material, the labor cost of the workers with respect to the time required to depaint, and the cost of waste treatment and disposal. The environmental impact included an assessment of the relative hazardous nature of the waste generated from each depaint method and the hazardous environment that it presented to the workers.

The study of the various paint removing methods took place between July and November 1985. The observations of chemical stripping were held at McClellan Air Force Base, Sacramento Air Logistics Center (SAALC), Sacramento, California, between July 24 and July 26, 1985. The observations of sandblasting and the demonstration test of PMB were held between October 23 and November 1, 1985, at the Sacramento Army Depot (SAAD). The same type of equipment was depainted at both facilities. Both the Sacramento Army Depot (SAAD) in Sacramento, California, and McClellan AFB volunteered their depainting areas for the observations of chemical stripping and sandblasting. SAAD also volunteered space and equipment for the PMB evaluations.

SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

The following section presents the conclusions and recommendations arising from this study. These conclusions apply both to the subject of this study, military equipment depainting, and to commercial product depainting. The conclusions are both direct and indirect consequences of the technical results of the project. Where indirect conclusions are drawn, the reasoning is given. Recommendations arise primarily from the conclusions. However, some recommendations stand alone, arising from observations that may not suggest a specific conclusion. In such cases, the observation leading to the recommendation is presented.

2.1 CONCLUSIONS

It is concluded that the PMB process is an economically and environmentally viable alternative technology to chemical stripping and sandblasting for depainting some major pieces of equipment. In particular, it is a viable and desirable replacement for the current methods of depainting military communication shelters. The PMB process can be used on many substrates and in many areas that will not tolerate either chemical stripping or sandblasting. Specifically, the ability to depaint the interior of military shelters, as well as depainting many thin panels and inside access ports of various types, makes the process an economical substitute for both sandblasting and chemical stripping. It also generates a much smaller

volume of waste, and in a form more easily handled than from either of the other two depainting processes.

- The economics of the PMB process are strongly dependent on the recycle rate of media within the process. The system becomes economically competitive to sandblasting at a recycle rate of approximately 90 percent. At the 90 percent recycle rate and for three passes, the costs of the blast media and of waste disposal on a per-square-meter-cleaned basis becomes roughly equal to that of sandblasting and much less than that of chemical stripping.
- PMB is not economically advantageous over sandblasting unless special care needs to be taken. Special care is defined as masking, further sanding or touch ups, or concerns with warping, heat damage, or substrate erosion.
- PMB can not be substituted for sandblasting where sandblasting is used primarily for corrosion removal.
- The PMB process will require special enclosed facilities similar to those used for sandblasting. A recovery and abatement system for fine dust will be mandatory, as paint pigment and heavy metals appear to concentrate in the dust "fines".
- Operators will require slightly more training than that required of sandblasters.
- PMB is the method of choice over chemical stripping in all cases where the stripper is sprayed on large surfaces. PMB requires less labor, less process time, and generates less toxic waste than chemical stripping. The process is also less dangerous to personnel and requires less material support.

2.2 RECOMMENDATIONS

It is recommended that EPA consider PMB the best available technology (BAT) for many depainting requirements. This would include all substrates currently chemically depainted except for small pieces normally tank dipped in large batches.

Although the plastic media is normally considered to be inert, it is recommended that a study be undertaken to establish the toxicity and hazard potential of the dust from the PMB process. Specifically, the explosibility and leachability of the dust should be established. A follow-on to this recommendation would be the exploration of alternative control and abatement options for the dust. From a treatment perspective, the following questions should be answered:

- Can the waste material be incinerated?
- What are the products of incineration?
- Can heavy metals be recovered or pacified?
- Can the waste material be used as a fuel supplement?

Further research on PMB is needed to determine possible effects of the blasting with plastic media on subjects made of soft metals and complex substrates.

SECTION 3

COMPARISONS OF THREE METHODS OF PAINT REMOVAL

The purpose of this section is to compare PMB with sand blasting and chemical stripping. The approach is to define operating parameters and the economics of the PMB depainting process on the Army communications shelter and to compare the results with those of the sandblasting and chemical stripping processes. Details of the observations on which the following comparisons are based are given in Section 4.

Although this study was originally designed to compare three processes, four processes emerged. The fourth process is hand sanding. Hand sanding was required to complete the depainting of the equipment under study for both the chemical stripping process and the sandblasting process. Thus, hand sanding represents a significant effort that was not necessary with the PMB process.

3.1 INTRODUCTION

Similar substrates for chemical stripping, sandblasting, and PMB were depainted for each observation. The major areas investigated during the observations included the number of man-hours needed to clean the object, the quantities of materials used, the amount of waste produced, and the quality of the finished material. Also determined were the types and amount of additional equipment used in each depaint process.

The cleaning rate (m^2/min) for the three depainting processes were determined by timing the cleaning of a measured surface area. Stripping speeds and environmental impact were determined using elapsed times and analytical results, respectively. Times were based on "nozzle on" times for blasting operations, and spraying, setting and rinsing elasped times for chemical stripping. The cost of treating or disposing of the wastes produced by each depainting method were estimated by measuring the amount of waste generated from a fixed surface area and multiplying by the unit cost for treatment or disposal. Unit costs were obtained by contacting disposal companies in California (Ref. 2). There was also an assessment of the surface quality of the shelters for each depainting method. The quality requirements for the surface finish were defined by military specifications, (MIL-4-14072C Sec 4.6.2, 19 April 1976) with surface quality being evaluated by facility QC inspectors.

3.2 DESCRIPTION OF PROCESSES

3.2.1 Plastic Media Blasting (PMB)

PMB is a relatively new method of paint removal. PMB is a unique variation of the sandblasting process employing plastic beads rather than sand. The plastic beads have a specific gravity of 1.5 and a Mohs hardness of 3 to 4. They normally have an irregular shape with sharp edges. PMB is applied at a pressure of 20 to 40 lb/in^2. Using pnuematic pressure, the media impacts upon the surface and attacks the paint covering the substrate. The plastic beads are harder than the paint but softer than the substrate, this allows the plastic beads to attack and break the paint layer on the surface without harming the substrates. PMB can be used, therefore, on a wide variety of substrates, even those substrates which can be easily

damaged by sandblasting. PMB can also be used on surfaces normally requiring chemical stripping and can eliminate the hazardous waste residues generated by chemical stripping.

3.2.2 Chemical Stripping

Chemical stripping involves applying a liquid solvent to the object by spraying, painting, or dipping. The stripper is allowed to set until the paint softens. The softened paint is then removed either by scrubbing with brushes or with jets of water. This sequence is repeated until all layers of the paint are removed and the surface of the object passes inspection. The object being stripped is cleaned down to the bare metal and rinsed off.

3.2.3 Sandblasting

Sandblasting is the impacting of a particulate media (sand) onto a surface using pnuematic pressure. The specific gravity of sand is 3.5 and the Mohs hardness is approximately 7. Sand is usually blasted at 70 to 80 psi. Sandblasting as with PMB relies upon the abrasive nature of the sand particles to break the paint layer and erode the paint from the substrate. This process is continued until the paint is completely removed from the surface. The residual sand and paint dust combination is collected and disposed of in an environmentally acceptable manner.

3.3 COMPARISON OF THE PROCESSES

The ability to recycle and reuse the media is one of the primary benefits of PMB. During the demonstration test, the plastic media was recycled up to three times. Most sandblasting operations do not attempt to recycle the media or waste products. In the past, the waste produced from sandblasting has not been considered toxic or hazardous under the current definitions of hazardous waste, thus, the waste sand is either left on the

premises or trucked to a landfill site. However, increasing public concern about hazardous waste will change this approach for sandblasting waste disposal. There is, of course, no way to recycle the paint strippers and solvents used in chemical stripping. These toxic wastes are discharged directly to water treatment systems.

A major concern of paint removal is that of waste generation and waste disposal. Table 1 presents the type and amount of waste produced and the disposal costs for each of the three depainting methods. The processing costs for chemical stripping waste were calculated by measuring the amount of water used in cleaning an item with the surface area of approximately 33 m^2. Costs were calculated based on estimated usage at the facilities under study. Water treatment costs were based on a facility treating 4.4 million liters a year with an operating cost of approximately $5000. Sludge and PMB costs were based on a current Class I landfill disposal rate of $35/170 L (45 gal) drum. A Class I Landfill is defined in the California Administrative Code, Title 23, Chapter 3, Subchapter 15, Article 3, Paragraphs 2530-2533. (Register 84, No. 49, 12/8/84). For costing PMB disposal waste, approximately 250 Kg of PMB (density 1.5) is expected to fit in a 170L drum. The drum is disposed at a Class I site for $35. Sand disposal costs were calculated based on a figure of $2100 to dispose of 82,000 Kg (90 tons). The amount of waste for sandblasting was based on the rate of sand usage for an item of approximately 33 m^2. The costs of disposal for all of the depainting processes are based on known disposal costs in California (Ref. 2).

TABLE 1. WASTES COSTS BY PROCESS FOR 100 m^2

Method	Waste product	Amount (per 100 m^2)	Cost of disposal ($/100 m^2)
Chemical stripping	Water	95,000 L	120[a]
	Sludge	550 L	112[b]
Sandblasting	Sand/paint	545 Kg	6.40[c]
PMB	PMB/paint	120 Kg	17.50[d]

[a]0.125¢/L (0.5¢/gal)
[b]$35/175L drum
[c]$2100 for 90 tons
[d]$35/175L (50 gallon drum with a plastic media density of 1.5 Kg/L)

During the demonstration test with PMB, approximately 450 lb (201.5 Kg) were used to blast an area of 33 m^2 with a recycle rate of about 80 percent. Only 90 lb (40.9 Kg) of plastic media dust and paint waste were produced while blast cleaning this area. As mentioned above, disposal at a Class I landfill for this type of waste will be at a rate of about $35/bbl. Because the material has a high carbon content it may be incinerable or cofireable in boilers with a heat content of medium-grade coal. Research is under way to determine the problems of incineration and/or cofiring PMB waste products. If the waste product can be incinerated or cofired with no hazardous emissions, it would significantly reduce or eliminate PMB waste disposal costs.

Chemical stripping generates contaminated water that must be treated. In this study, an average of 300 L/m^2 per surface area depainted was generated. This contaminated water must be pretreated before discharge to a

public-owned treatment facility (POTW). For a 20,000 L/day generator the cost is estimated to be about $0.001/L (0.5c/gal) (see above). Hazardous sludge is also produced from the softened paint and stripper mixture. This sludge must be treated or disposed of at a hazardous waste disposal site. The costs of treatment and/or disposal of this hazardous material can be in the thousands of dollars for a facility producing approximately 10,000 to 20,000 gal of waste a month.

The used sand from sandblasting is, at present, significantly less costly to dispose of than either the wastes from chemical stripping or the projected wastes from PMB. Even though the waste sand has been reclassified as a "special waste" in the state of California, the costs of disposal have not increased. This may change in the future. Futhermore, if the sand plus paint waste contains greater than 6 percent leachable lead, the disposal cost could be up to $280/ton at current prices. Therefore, the economic impact of PMB versus sandblasting based upon waste disposal costs must be made in light of local disposal regulations and waste classification.

Table 2 is a summary of the equipment depainted for this study. It shows the surface areas cleaned, the time required, and the calculated rate for each shelter and each process. In Table 3, PMB is shown to be faster than either chemical stripping or sandblasting when both require additional hand sanding. The faster rate of PMB (approximately 0.18 m^2/min) results in lower labor costs and higher productivity. Estimates of labor costs for the four processes are presented in Table 3. For PMB, the figures were based on the average time required during the demonstration test to clean an area of 100 m^2 using inexperienced operators. This is the surface area of one size

TABLE 2. EQUIPMENT CLEANED IN PROJECT

	Equipment item	Total area cleaned (m^2)	Total clean time (min)	Rate (m^2/min)
Chemical stripping	1[a]	31.86	701.8	0.045
	2	16.81	1125.7	0.015
	3	35.99	1345.1	0.027
Sandblasting	4	17.68	24.4	0.725
	5	17.68	26.7	0.662
	6[a]	17.68	66.0	0.268
	7	22.22	33.0	0.673
	8[a]	22.22	67.3	0.330
	9	22.22	23.8	0.934
Hand sanding	10	6.6	97.1	0.068
	11	3.35	50.0	0.067
PMB	12[a]	61.06	440.5	0.139
	13	33.05	221.0	0.150
	14	33.05	229.8	0.144
	15[a]	68.82	258.5	0.266
	16[a]	33.05	160.3	0.206

[a]Item painted in camouflage pattern.

of equipment depainted by all three methods. Sandblasting, at first glance, appears to be the fastest process. However, the entire procedure of cleaning a shelter using sandblasting is not as rapid as indicated. The interior of the equipment must be hand sanded because sand blasting leads to warpage and delamination. An exterior area of 33 m^2 was depainted in approximately 30 min by sandblasting. However, when sandblasting is combined with hand sanding of the interior, the time required increases dramatically. The hand sanding rate was determined to be approximately 0.07 m^2/min. By using a 50/50 mix of surface area hand sanded and sandblasted, the rate for sandblasting is put on the same basis as using PMB for both interior and

TABLE 3. MAN-HOURS NEEDED PER DEPAINTING METHOD[a]

Method	Time (min) (per m^2)	Average (pay/hr ($))	Dollars (per 100 m^2)
Chemical stripping	34.5	17.60	624.36
Sandblasting	2.0	15.89	17.48
Hand sanding	9.3	15.89	131.09
Sandblasting plus hand sanding[b]	7.7	15.89	122.79
PMB	4.9	15.89	42.82

[a]Based on the amount of time to clean 100 m^2 aluminum painted with laquer paint.
[b]50 percent surface area sandblasted and 50 percent surface area hand sanded.

exterior cleaning. Hand sanding is not required with PMB because PMB can be used on the interior without warpage or delamination occuring. This assessment showed that PMB is the fastest process. Also, from Table 2 it can be seen that chemical stripping is the longer process (approximately 0.03 m^2/min). This is due to the need for repeat applications of the stripper and the necessary set times to allow the stripper to work. In addition, chemical stripping cannot be used on the interior because of corrosion and attack on electrical wiring insulation by the solvent. Chemical stripping thus requires hand sanding also.

The estimated operational costs of the three depainting methods are based on the material costs, the time needed for depainting (i.e. labor costs) and cost of treating or disposing of the waste products. Costs not accounted for on any of the processes include capital equipment and support

labor and management. Table 4 compares the three determined costs (labor, media, waste) for each depaint method. It gives an estimation of the costs for an area of 100 m^2 cleaned by each of these paint removing methods. Labor costs are estimated from the average salaries of depaint workers and the average time needed to depaint a given surface area. The cost of the waste disposal and treatment is based on the average amount of waste produced for each depainting method. The cost for the cleaning materials, solvent, sand and plastic beads, is based on the average amount used per unit area. Table 4 shows the cost summaries for these categories for each depaint method.

All three of these paint removing methods are potentially hazardous to the workers health. The sand dust produced by sand blasting contains silica, which can, if inhaled, cause silicosis (Ref. 3). Chemical stripping could be considered more hazardous due to the potential to absorb toxic or hazardous materials through the skin as well as by breathing, and the potential for the worker to get chemical burns (Ref. 4). For this reason, people who work in chemical stripping operations must be protected from head to foot with rubberized suits and protective face respirators. Any of the PMB waste generated will show evidence of the presence of priority pollutant metals if they are contained in the paints being stripped. In addition, all three of these paint removing methods will require wearing protective equipment.

One of the major concerns for paint removal technologies is the quality versus the efficiency of depainting. Efficiency is measured by the amount and rate of paint removal. Quality is determined by any resultant effect on the substrate surface. PMB will remove the paint entirely from an aluminum substrate with no observable damage to the substrate. Thorough testing has

TABLE 4. ESTIMATED OPERATIONAL COSTS PER DEPAINT METHOD FOR 100 m^2

Method	Labor costs ($/100 m^2)	Cost of cleaner ($/100 m^2)	Cost of waste treatment ($/100 m^2)	Total cost ($/100 m^2)
Chemical stripping	1012	3612	232	4856
Sandblasting	204	600	14.20	818
PMB	130	486	18.00	634

shown that blasting with PMB has no detrimental effect on metal surfaces since metal typically is not eroded from the substrate nor are undesirable chemical conditions imparted to the surface (Ref. 5).

Sandblasting does affect the metal surfaces. The surface layer of metal is roughened and pitted by the sandblasting process. For aluminum surfaces this is caused by actual removal of material from the metal surface by the sandblasting process. Sandblasting may cause delamination of thin bonded metal substrates from the heat produced by blasting. PMB when properly adjusted will not result in metal abrasion or delamination.

Chemical stripping manages to remove the majority of the paint from a metal substrate with little negative effect to the substrate. Often, however, some paint is left on complex areas, such as rivetting. This paint is either removed by hand sanding or is painted over. After chemical depainting, the metal surface must be rinsed with water to remove the stripper. Before repainting, the shelters are rinsed with an alkaline solution to counteract any possible effect stripper residue may have on the new paint coat. It is the use of chemicals and their eventual requirements

for treatment that is the major disadvantage of chemical stripping over PMB. Chemical paint removal will require the use of significant volumes of water for rinsing and dilution: all of which will eventually require some form of treatment before discharge.

Although chemical stripping does not seem to affect metal substrates, there is concern about its effect on composite surfaces, such as fiberglass. The chemicals in the stripper often attack the bonding of these substrates. Properly used PMB does not present this problem.

SECTION 4

OBSERVATIONS AND TESTS ON MILITARY COMMUNICATION SHELTERS

4.1 INTRODUCTION

This section contains the specific information gathered from the observations of chemical stripping, sandblasting and hand sanding, and the PMB demonstration test. The information presented was obtained during the application of depainting processes to military communication shelters. Shelters are depainted for repair and refurbishing. The section will begin with a description of the communication shelters and will be followed by a discussion of each depainting process as it was applied to the shelters. The discussion of each paint removing process will include the procedure followed to gather information during the observations and the demonstration test.

4.2 SHELTER DESCRIPTION

The equipment depainted during the observations and in the demonstration test were military communication shelters. There were two sizes of shelters used in the study -- a small shelter similar to a pickup camper called a six-pac, and a medium-sized shelter. They were constructed from sandwich panels of aluminum skins (0.040 in. exterior and 0.032 in. interior thickness) bonded to a foamed plastic core. The aluminum skins were secured to girder structural members by bonding, riveting, welding, or a combination of these methods (Ref. 6). Table 5 gives a summary of the shelters cleaned

TABLE 5. DESCRIPTION OF SHELTERS CLEANED

	Shelter	Size category	Dimensions length x height x width (m)	Camouflange paint
Chemical stripping	#TSC60	Medium	3.45 x 2.19 x 2.10	X
	#TRC97A	Small	1.74 x 1.74 x 1.80	
	#RCA34	Medium	3.84 x 2.25 x 2.10	
Sandblasting	GRC-142 (788)	Small	1.83 x 2.28 x 1.80	
	GRC-142 (870)	Small	1.83 x 2.28 x 1.80	
	GRC-142 (490)	Small	1.83 x 2.28 x 1.80	X
	TRC-117 (T68-099-97)	Medium	3.54 x 1.95 x 2.13	
	TRC-117 (T68-099-45)	Medium	3.54 x 1.95 x 2.13	X
	TRC-117 (05)	Medium	3.54 x 1.95 x 2.13	
PMB	T68-340-10	Medium	3.54 x 1.95 x 2.13	X
	1132	Small	1.83 x 2.28 x 1.80	
	138	Small	1.83 x 2.28 x 1.80	
	139	Medium	3.54 x 1.95 x 2.13	X
	0329A	Small	1.83 x 2.28 x 1.80	X

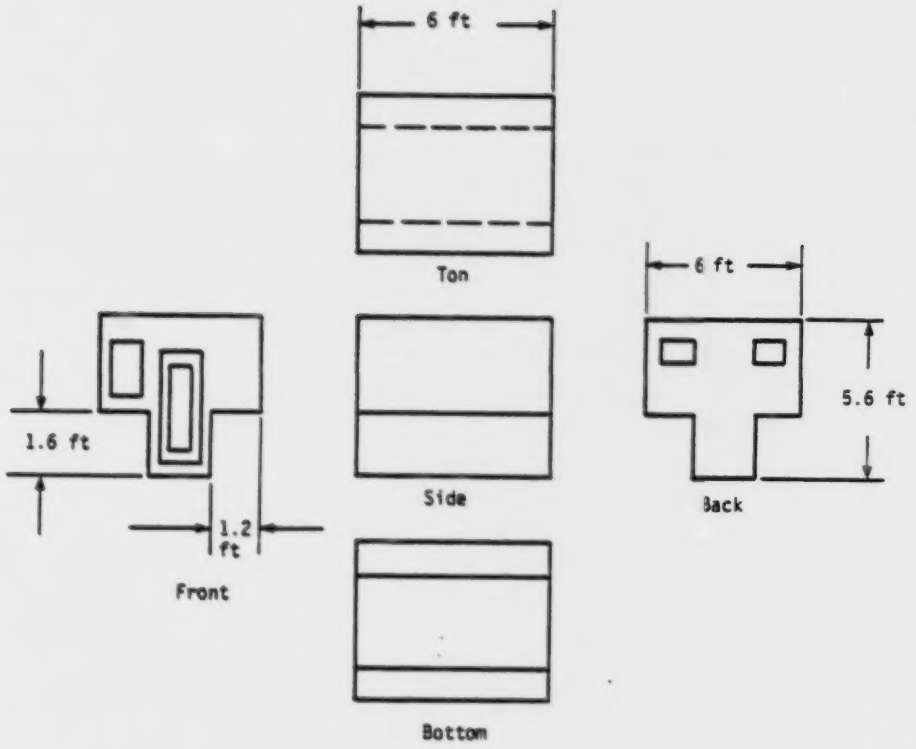

Figure 1. Small-sized communication shelter.

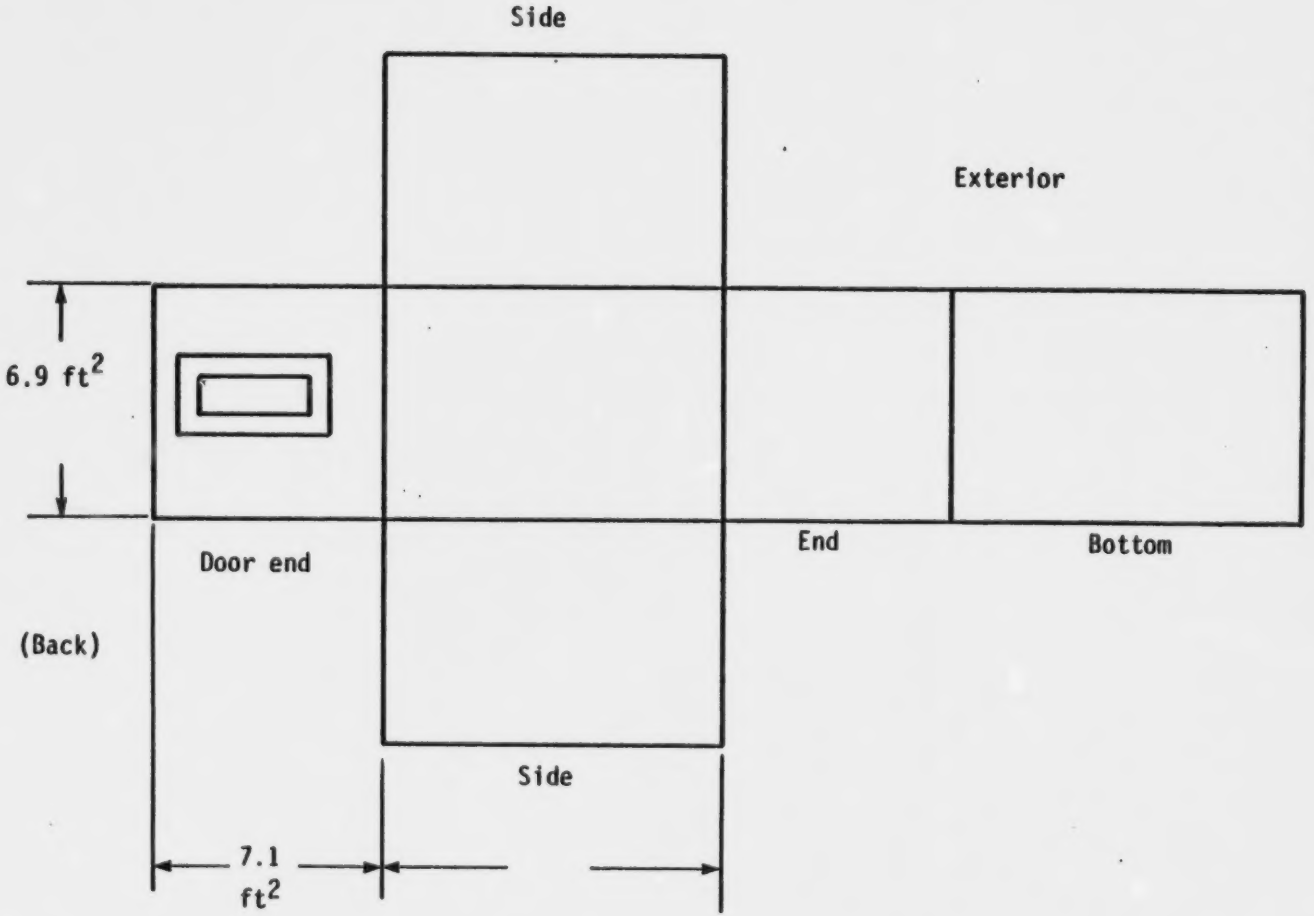

Figure 2. Medium-sized communication shelter.

during this project and their respective sizes. Figures 1 and 2 diagram the typical shelters. The approximate surface areas are 35.81 m^2 and 18.37 m^2 for the exterior of medium and small units, respectively. All of the shelters in the study were coated with alkyd enamel paint. The shelters that were chemically stripped had all openings masked to prevent intrusion of solvent. Similarly, the ventillation port metal panels of the sandblasted shelters were masked to prevent intrusion of sand into the interior of the shelter and warpage of the metal flaps. The PMB shelters were not masked in any way.

4.3 CHEMICAL STRIPPING

4.3.1 Introduction

The observations and data collecting for the chemical stripping process were conducted at SAALC from July 24 to July 26, 1985. Three communication shelters were depainted. The average depainting rate was 0.03 m^2/min. Table 6 gives an overview of the time needed to strip a shelter and the amounts of stripper, solvents, and water used. This data applies only to the exterior of the shelters. The interiors of the shelters were not chemically stripped, as the solvents can damage wiring. The paint is usually removed from the interior of the shelters by hand sanding.

One small and two medium-sized communication shelters were cleaned at the rate of one shelter per day. The surface area of each shelter was measured and recorded before each depainting operation. The time required for each step in the depaint process was recorded from the moment the unit was retrieved from the holding area until the final rinse down of the depaint area. Detailed records were taken of the amount of time spent applying the solvents, scrubbing the shelters, and rinsing down both the shelters and the

TABLE 6. SUMMARY OF CHEMICAL STRIPPING AND THE CHEMICALS USED

Shelter	Total area (m^2)	Total clean time (min)	Total amount stripper (Kg)	Total amount water (ℓ)	Total amount MEK (Kg)	Ft^2 cleaned (per min)
#TSC60	31.9	691.8	58.6	5972.8	28.5	0.046
#TRC97A	16.8	1125.7	63.6	8877.6	3.3	0.015
#RCA34	36.0	1345.1	165.8	10,016.9	0.2	0.027

depaint area. Solvent and water usage were estimated by measuring the pounds per second flowrate. The raw data is presented in Appendix A. The depaint chemical used met Mil Spec No. MIL-R-25134. There were up to three people on each crew. In determining the amount of time at a particular activity, the number of people engaged in that activity was taken into account. Therefore, if two or more people were engaged in an activity at the same time, then the amount of time spent at the activity was multiplied by the number of people involved.

Charcoal tube and Draeger detection tube samples were taken during the chemical stripping process by the National Institute of Occupational Safety and Health (NIOSH) personnel. The charcoal tube samples were taken at various distances from the shelter being stripped (<0.1 m to 15 m). These sample tubes were used to capture VOC samples for later analysis. The tubes were also placed on the workers as they either applied the stripper or scrubbed the shelter. The Draeger tube samples to measure methylene chloride were taken close to the working area. Samples of the water were taken both

in the wash stream and from the sump or holding tank. The results from the charcoal and Dreager tube samples and water samples are presented in the appendices.

4.3.2 Observations and Results

Table 7 is an outline that describes the general procedure of a depaint operation at SAALC. The doors on the front and the panels along the sides were masked with duct tape to prevent solvent or water intrusion into the shelter. The chemical stripper is sprayed on the shelter surface and allowed to set until some effect is seen; usually the paint "bubbles" and loosens from the metal. The paint is then scrubbed or rinsed from the surface and, if there are remaining layers of paint, the process is repeated. This process generally takes two to four people at least one full shift (8 hours) to clean the exterior of one shelter.

Table 8 shows the total material use of chemical stripper, methyl ethyl ketone (MEK) and water during the 3 days of observation. Also listed is the usual amount of equipment used weekly by one person at this depaint area. The equipment includes the protective clothing and respirators, along with the tape needed for masking and the brushes needed for scrubbing.

On the first day of the observations, July 24th, the temperature reached 37°C. The heat affected the depaint process in two ways. First, the heat caused chemical solvent to react with the paint more rapidly. Within 5 to 10 min after application, the paint was visibly loosened from the shelter. Secondly, OSHA regulations for protection of workers handling chemical solvents require workers to be completely covered. The workers wore a full coverall, rubber boots, full rain gear, complete head protection and rubber

TABLE 7. OUTLINE OF THE CHEMICAL STRIPPING PROCEDURE

Activity	Compound	Duration (min)
Move to depaint area and finish taping		30
First Spray	MIL-R-25134	~10
Set		~30
Scrub with long-handled brushes		~5
Rinse down of depaint area	H_2O	1-5
Second Spray	MIL-R-25134	~10
Set		30-60
Scrub with long-handled brushes		~30
Rinse down of depaint area	H_2O	1
Third Spray	MIL-R-25134	~5
Scrub with long-handled brushes		~3
Rinse down of depaint area	H_2O	1
Rinse down of shelter	H_2O	10
Scrubbing	MEK	~1
During scrubbing, several short rinses of area		~5 total
Spot spray on difficult areas	MIL-R-25134	~5 total
Scrub continues		~30 total
Final rinse of shelter area		~10
*If difficult to remove the paint, will spray with phenolic stripper at this point.		~2
Rinse down of area	H_2O	3
Set		30
Scrub		7
Second spray		4
Second scrub		12
Final rinse of shelter and area	H_2O	9

TABLE 8. TOTAL MATERIAL USAGE

Object cleaned	Stripper (Kg)	MEK (Kg)	Water (l)	Equipment used (per person/week)
Shelter TSC60	58.6	28.5	5972.8	1 rain suit 20 to 30 paper hoods 5 pair goggles
Shelter TRC97A	63.6	3.3	8877.6	5 shields 10 pair gloves (plastic) 2 to 4 pair gloves (rubber)
Shelter RCA34A	165.8	0.2	10016.8	5 pair coveralls (recycled) 2 rolls metal masking tape 25 "toothbrushes" (100/box/mo) 2 hand brushes 3 to 4 handle brushes/mo ~20 to 25 respirators (recycled)
Total	288.0	32.0	24,867.2	
Average Shelter	95.9	10.8	8,284.0	
X 5 Days	495.0	54.0	41,800.0	

gloves. This caused their body surface temperature to reach 38°C. The workers thus tired quickly and required numerous breaks to cool down or rinse off.

The first shelter (TSC 60) to be depainted was sprayed with the chemical stripper three separate times. The loosened paint was scrubbed off after each application. The entire depaint area and the shelter itself was rinsed off with a high-pressure, hot-water hose. The shelter was moved into a more shaded region of the depaint area. Difficult access areas were scrubbed using MEK and small hard brushes ("toothbrushes"). Areas that are considered difficult to access were small overhangs at the bottom of the shelter or the actual roof of the shelter. The scrubbing continued for 1 hour. During the last half hour, the masking tape was removed and these areas were sprayed with chemical stripper. When the shelter was considered clean, it was rinsed with water.

Table 9 shows the area of the shelter, the amount of time it took to clean each section of the shelter, and the amount of solvents and water used during the cleaning process. Table 10 compares the total amount of time needed to clean the shelter with the actual time spent in applying the stripper, scrubbing the shelter, and rinsing the depaint area and the shelter. The large discrepancy in total clean time relative to spraying, scrubbing, and rinsing is due partially to the setting time of the chemical solvent after application.

The second shelter to be cleaned was classified as a small shelter (TRC97A). However, in this case, the paint proved to be more difficult to remove. The shelter was sprayed with the chemical stripper twice. The loosened paint was removed by scrubbing and then rinsing with the high

TABLE 9. COMMUNICATION SHELTER #TSC60

Panel	Total area (m^2)	Total clean time (min)	Total amount stripper (Kg)	Total amount water (l)	Total amount MEK (Kg)	Ft^2 cleared (per min)
Right side	7.78	136.1	15.8			0.057
Left side	7.78	138.1	14.9			0.056
Front	4.54	131.9	12.6			0.034
Back	4.54	137.5	9.2			0.033
Top	7.22	148.3	6.3			0.049
Total	31.86	691.9	58.6	5972.8	28.5	0.046

pressure hose. This sequence was followed by the workers scrubbing the difficult areas with toothbrushes and MEK. Several sections (mainly along the edges) were extremely resistant to the usual chemical solvent and to MEK. The workers decided to use a stronger chemical solvent which contained phenols. When using this stripper, a worker must, along with the normal protective clothing, wear rubber gloves and head gear and a full-face respirator. The phenolic stripper was sprayed on and allowed to set for approximately 30 min. Then, the loosened paint and stripper were scrubbed off. The final action was to rinse down the shelter and the depaint area with a high-pressure water hose. Table 11 gives the surface area of Shelter TRC97A, the amount of time needed to strip each section of the shelter, and the amount of solvent and water used during the cleaning procedure.

TABLE 10. BREAKDOWN OF DEPAINT TIME

Shelter	Total area (m^2)	Total clean time (min)	Actual time to apply stripper	Actual time scrubbing
TSC60				
Right side	7.78	136.1	6.4	
Left side	7.78	138.1	6.0	
Front	4.54	131.9	5.1	
Back	4.54	137.5	3.7	
Top	7.22	148.3	2.5	
Total	31.86	691.9	23.7	134.9
TRC97A				
Right side	3.84	211.4	4.0	
Left side	3.84	214.7	3.7	
Front	2.90	220.8	3.5	
Back	2.90	209.5	4.9	
Top	3.33	209.5	5.3	
Total	16.81	1065.8	21.4	119.1
RCA34				
Right side	8.98	252.4	10.2	
Left side	8.98	289.9	6.4	
Front	4.85	298.1	10.1	
Back	4.85	251.9	6.0	
Top	8.33	253.5	4.0	
Total	35.99	1344.9	36.7	70.9

TABLE 11. COMMUNICATION SHELTER #TRC97A

Panel	Total area (m^2)	Total clean time (min)	Total amount stripper (Kg)	Total amount water (l)	Total amount MEK (Kg)	Ft^2 cleared (per min)
Right side	3.84	211.4	11.8			0.018
Left side	3.84	214.6	11.0			0.018
Front	2.9	220.8	10.4			0.013
Back	2.9	209.5	14.7			0.014
Top	3.33	209.5	15.7			0.016
Total	16.81	1065.8	63.6	8877.6	3.3	0.016

The third shelter (RCA34) was classified as a medium-sized communication shelter. The shelter, like the previous two shelters in this series was coated with enamel paint. The initial coat of solvent was applied and allowed to set for 30 min. After that length of time, patches of the paint down to bare metal were beginning to fall from the shelter. The shelter was scrubbed down, resprayed, and allowed to set for 2 hours. Most of the paint was removed within this time, except for the difficult accesses and the complex areas (such as rivetted areas). These areas were then scrubbed with the small hand brushes and MEK until they were considered sufficiently clean. There was a final rinse down of the shelter and the entire depaint area. Table 12 describes the areas, total clean time, and the amounts of solvent, MEK, and water used to clean the third shelter.

4.4 SANDBLASTING

4.4.1 Introduction

The observations and data collecting for the sandblasting operation were conducted at SAAD on Oct. 23, 1985. Three small and three medium-sized communication shelters were depainted by sandblasting during this observation period. The total surface area of both sizes of shelters was measured and recorded. The amount of time to blast clean each section of a shelter was also recorded. Ventilation panels on the shelters were not sandblasted. Depending on the size of the shelter, the area of these panels ranged from 0.17 to 0.50 m^2. The area of the panels was not included in the total area of the shelters when calculating the average blast time. Table 13 gives a summary of the shelters sandblasted for this series of observations. The summary includes the areas of the shelters depainted, the total blasting time, and the average depainting rate for each shelter.

The amount of sand used was estimated by multiplying the pounds of sand used per minute by the time needed to clean the shelter. This number was cross checked by monitoring the number of sand bags used, since the sand was not recycled. Approximately 180 Kg of sand is used to clean the outside of a small shelter.

Charcoal tube samples for volatile organics were taken at a stationary location and were also placed on the workers to get personnel samples. The stationary location was between the two shelters being depainted. There was an attempt at sampling the particulate content in the air during the sandblasting. However, the amount of dust produced by the sandblasting

TABLE 12. COMMUNICATION SHELTER #RCA34

Panel	Total area (m^2)	Total clean time (min)	Total amount stripper (Kg)	Total amount water (l)	Total amount MEK (Kg)	Ft^2 cleared (per min)
Right side	8.98	252.4	45.0			0.036
Left side	8.98	289.1	28.4			0.031
Front	4.85	298.1	44.5			0.016
Back	4.85	251.9	26.6			0.019
Top	8.33	253.5	21.3			0.033
Total	35.99	1,345.0	165.8	10,016.8	0.2	0.027

TABLE 13. SUMMARY OF SANDBLASTING RATE

Shelter	Total area (m^2)	Total blast time (min)	Cleaned (m^2/min)
GRC-142 (788)	17.67	24.4	0.724
GRC-142 (870)	17.67	26.7	0.661
GRC-142 (490)[a]	17.67	66.0	0.268
TRC-117 (T68-099-97)	22.33	33.0	0.677
TRC-117* (T68-099-45)	22.33	67.3	0.332
TRC-117 (05)	22.33	23.8	0.937
Total	120.00	241.3	0.497

[a]Shelter painted in a camouflage pattern.

proved to be in excess of the capabilities of the equipment and the procedure to measure (Ref. 7). Samples of waste were taken and analyzed for 14 priority pollutant metals.

The following procedure was used for evaluating the shelters. The shelters were inspected by SAAD QA/QC personnel prior to sandblasting to identify any pre-existing holes, delamination, or corrosion. The shelters were then moved to the blasting booth and the outsides were blasted clean. Then the shelters were moved to the outside of the hand-sanding area and reinspected for any new holes, delamination, and corrosion. The interior of the shelters was then hand sanded, and any holes or other problems were repaired.

Sandblasting has been verified as a health hazard (Ref. 3). Workers without proper protection can contract silicosis, a lung disease which is caused by breathing silica dust produced by sandblasting. To counter this threat, people who handle sand-blasting equipment are covered by protective head gear with an external air supply.

4.4.2 Observations and Results

Six shelters were sandblasted during one shift. The entire outside area, including the top and bottom of the small shelters, was blasted clean. The thin panels that cover ventilation screens and communication power outlets were not sandblasted as the metal was too thin (from 0.016 to 0.050 mm) and would be easily warped or damaged by the force of the sand-blasting process.

During the initial blasting sequence two shelters were depainted: Shelter numbers GRC-142(788) and GRC-142(870), respectively. Tables 14 and 15 give the breakdown of the respective depainting times for each side of the

TABLE 14. SANDBLASTING TIME OF GRC-142 SHELTERS

Panel	Area (m^2)	Blasting time (min)			Average blast time (ft^2/min)
		Shelter 788	Shelter 870[a]	Shelter 490	
Right side	3.81	5.18	5.35	19.65	0.379
Left side	3.81	6.08	4.12	13.32	0.486
Back	2.70	3.43	3.08	6.37	0.628
Front	1.86	3.53	6.85	13.27	0.236
Bottom	2.05	2.0	1.78	4.45	0.746
Top	3.35	4.23	3.82	8.97	0.590
Total	17.57	24.42	25.73	66.02	0.454

[a]Shelter painted in a camouflage pattern.

TABLE 15. SANDBLASTING TIME OF TRC-117 SHELTERS

Panel	Area (m^2)	Blasting time (min)			Average blast time (ft^2/min)
		Shelter -97	Shelter -45[a]	Shelter 05	
Right side	7.25	10.47	19.48	7.43	0.582
Left side	7.25	9.5	21.17	6.67	0.583
Back	3.53	7.58	13.15	5.08	0.411
Front	4.28	5.45	13.5	4.83	0.540
Total	22.32	33.0	67.3	23.82	0.539

[a]Shelter painted in a camouflage pattern.

shelters. There were two men working, one blasting each shelter. The front, back, and right and left sides were blasted first. Then the shelters were turned over to blast the top and bottom areas.

The second blasting sequence cleaned one small-sized and one medium-sized shelter, TRC-117 (T68-099-45) and GRC-142 (490), respectively. The medium-sized shelter (TRC-117) was sandblasted on the front, back, and the right and left sides only. This shelter was not turned over to blast the top and bottom. The small-sized shelter (GRC-142) was painted in a camouflage pattern and the paint removal was slow relative to the uniform pattern of the other shelter (compare Tables 14 and 15). The person blasting the medium-sized shelter finished first. He then helped to complete the small-sized shelter which was then turned over to permit depainting of the top and bottom of the shelter. The medium-sized shelters did not have the door and bottom depainted. Normally, they would be removed from the sandblasting booth, turned on their side, and moved back into the booth.

The third blasting sequence cleaned two medium-sized shelters: TRC-117 (T68-099-45) and TRC-117 (05). Both shelters were sandblasted on the front, back, and the right and left sides. The top and bottom were not sandblasted. Shelter 45 was painted in a camouflage pattern. Table 15 shows that it took more than twice as long to sandblast Shelter #45 compared to Shelter #05. When the person blasting Shelter #05 finished, he helped to complete Shelter 45.

Table 13 compares the blast time of all of the shelters that were sandblasted. One note of interest is that the larger shelter with the larger area took an equivalent time to clean as the smaller shelters. The smaller

shelters, although they had less surface area, had a more complex area to clean. The GRC-142 shelters had an indentation of 0.54 meter on both sides. This gave the operators two small areas of 0.69 m^2 and 0.89 m^2 on each side to blast clean. It took an operator slightly longer to clean two areas and the joining corner than an equivalent flat area.

4.5 HAND SANDING

4.5.1 Introduction

Observations of hand sanding operations were done on Oct. 25 and 28 at SAAD. The observations lasted 4 hours each day. OSHA regulations prohibit a worker from being continuously exposed to the sand and paint dust for more than 4 hours. Only small-sized shelters were observed for hand sanding. One person sanded the interior while another performed the necessary repairs. The hand sanding was done with hand-held sanders that were pnuematically powered. Certain small panels and protective flaps were removed and hand sanded. These panels and protective flaps were masked during either chemical stripping or sandblasting.

Shelters that have been sandblasted or chemically stripped on the outside were then transferred to a hand sanding section for completion. The interiors of the shelters, even when completely disassembled, contained runways that protected electrical wiring. Sandblasting or chemical stripping of the interior could damage this wiring and other nonprotected installations. Also, the aluminum wall on the interior of the shelters were thinner than the exterior wall (0.032 in. versus 0.040 in. respectively) which also precluded sandblasting of these areas. These wall panels could be easily warped or delaminated from the internal support by the high pressure and high temperatures developed by sandblasting. For the previous reasons,

the interior of the sandblasted and chemically stripped shelters are hand sanded. Repairs on the shelter were conducted at the same time as the hand sanding. The repairs often needed on a shelter include patching holes caused by rough treatment in the field, cutting out and patching corrosion spots caused by water leakage in the field, and replacment of delaminated panels caused either in the field or during sandblasting.

4.5.2 Observations and Results

Table 16 shows the amount of time needed to hand sand relatively small sections of the shelter interior. Differences in time to clean an area are due to the number of layers of paint, the type of paint, and/or the condition of the paint. The last column in Table 16 shows that the average rate of paint removal for hand sanding is 0.10 m^2/min. Table 17 shows the extrapolated sander on time to clean the interior of the three shelter types that were used during this program. In actual applications, however, the cleaning time was not this rapid. Intricate areas around raceways and junction boxes required workers to sand in short bursts and to change sanding pads often. In most shelters, only relatively small areas were hand sanded, leaving much paint behind. The edges of paint left on the surface were then feathered into the base metal areas. The paint left on the surface was painted over producing an even thicker coat for the next depainting situation. Thus, elapsed time was often much longer than sander on time and the final product was not necessarily a clean, bare-metal surface. It was estimated that a small shelter (about the size of a GRC-142) will take an average of 8 hours or at least one shift to clean. The larger shelters could take up to an entire work week.

TABLE 16. HAND SANDING DATA

Object sanded	Area (m^2)	Time to sand (min)	Average cleaning time (m^2/min)
GRC-142 Obs. I			
Panel	0.14	4.7	0.030
Right wall	1.77	26.0	0.068
Left wall	2.01	22.7	0.089
Back	2.13	34.2	0.062
Bench	0.55	9.5	0.058
Total	6.6	97.1	0.068
GRC-142 Obs. II			
Back	0.742	10.4	0.072
Raised structure	0.096	4.4	0.022
Bench	0.652	12.5	0.052
Left wall	1.861	16.1	0.116
Total	3.351	50.0	0.067
Full Total	9.951	93.3	0.067

TABLE 17. EXTRAPOLATION OF HAND SANDING DATA TO ENTIRE SHELTER INTERIOR

Shelter	Area (m^2)	Estimated cleaning (m^2/min)	Estimated cleaning time (min)
GRC-142	16.56	0.107	1.77
GRC-117	36.59	0.107	3.92
GRC-110	36.74	0.107	3.93

4.6 PLASTIC MEDIA BLASTING

4.6.1 Introduction

The PMB demonstration test was conducted at SAAD between October 29 and November 1, 1985. An area of 90 m^3 in the repair and hand sanding building was enclosed with plastic sheeting. Windows of plexiglass were put in the plastic walls to permit observation of the PMB evaluations. The plastic enclosure was ventilated with two to three shop floor fans. A ventilation tunnel was installed to remove the dust from the blasting area. A furnace filter was installed in the vent to the outside to trap entrained dust.

Two blasting machines were used. The first machine was a standard Clemco sandblasting machine with a 45 Kg bin. This Clemco machine was operated at a pressure of approximately 30 to 40 psi. The second machine, which also had a 45 Kg bin, was made by Schmidt Manufacturing Inc., specifically for PMB. The Schmidt unit was a prototype with a vacuum recovery system attached close to the venturi blasting nozzle. It also had a water knockout separation system for bead recovery. Both units used a 1/2-in. nozzle, the same size used in the sandblast booth.

A total of five shelters (three small and two medium-sized shelters) were blasted clean. Two of the small and one of the medium-sized shelters were painted in a camouflage pattern. Table 18 compares the area and average blast times of the interior and the exterior of each shelter. The total outside surface area of the shelters was recorded along with the surface areas of all panels and openings. The interior surface area was extrapolated from the total outside surface area by subtracting the wall thickness from the exterior dimensions. The elapsed time to blast each surface was recorded. Each shelter was inspected for any corrosion, delamination, or

TABLE 18. COMPARISON OF PMB CLEANING RATE EXTERIOR VERSUS INTERIOR

	Total area (m^2)		Total time to blast		Average blast time (m^2/min)	
Shelter	Interior	Exterior[b]	Interior	Exterior	Interior	Exterior
T68-340-10[a]	21.90	31.90	147.0	201.0	0.149	0.159
1132	19.21	20.90	81.3	199.8	0.194	0.105
138	19.21	20.90	101.3	68.5	0.190	0.305
139[a]	37.95	32.09	196.0	122.5	0.236	0.262
0329A[a]	19.21	20.90	47.3	113.0	0.406	0.185
Total	117.48	126.69	572.9	704.8	0.205	0.180

[a]Shelter painted in camouflage pattern.
[b]Does not include bottom, does include panels and interior walls.
[c]Does not include bottom and right side. See test.

holes before and after the blasting. Samples of the fresh plastic media and media mixed with the paint dust were collected for analysis of priority pollutant metals. The entrained dust which settled in the filter tunnel of the ventilation system was sampled. Futhermore, samples of the water used in the media/paint/dust separation unit of the prototype Schmidt machine were taken.

4.6.2 Observations and Results

Table 18 compares the times to blast clean both the interior and the exterior of the shelters involved in the PMB demonstration test. The first shelter (T68-340-10, TRC-110) to be depainted took 2 days and an actual

blasting time of 12 1/4 hours to blast clean. The floor of this shelter was covered with a silica-impregnated rubber latex coating and took 5 hours to blast clean. The right interior side also took longer than the subsequent shelters due to operator experimentation with different nozzles and blast pressures. The second and third shelters were both small (eg. GRC-142) and thus both fit into the blasting area simultaneously and were blast cleaned sequentially. The last blasting sequence cleaned one medium-sized and one small-sized shelter, also, sequentially. The medium-sized shelter (139) was painted in a camouflage pattern. The camouflage did not significantly effect the blast time as it did during sand blasting. This shelter was blasted down to the bare metal both inside and out in slightly more than 5 hours. The final shelter (0329A) was cleaned entirely in 2.6 hours as shown in Table 18.

Several engineering observations were made with respect to the PMB demonstration test. Certain parameters were determined to be important to the efficiency of the PMB process. These parameters included the blasting angle, the distance from the substrate, and the blast pressure. Blasting inside the shelters resulted in the intrusion of media into wiring raceways, which then required vacuuming. An operational change, which speeded up the blasting of the interior of the shelters, was in the sequence of blasting. It was found that by blasting the floor before blasting the walls and ceiling, the entire operation moved faster. When the floor is done last, one must attempt to blast through the accumulated dust and media on the floor. The media was recovered from the floor of the work area and the bins of the blasting machines were refilled about every 30 min. After the third time the media was recycled, the effectiveness of the blasting process had dropped off

dramatically with the accumulation of dust-sized particles and with the wear on the media. At this point, fresh media was added to the system.

During the demonstration test, an attempt was made to test the ability of PMB to remove all paint except the primer. This was difficult because the paint and the primer were very close in color and it was hard to differentiate between the two coatings. Visibility was poor in the blasting area because of the fine dust that filled the enclosed blasting area.

The chemical analysis of the paint dust, depicted in Table 19, showed significant levels of chromium, lead, nickel, and zinc. Consequently, workers who use PMB should wear the same protective gear as sandblast operators. The lack of adequate ventilation could increase the danger to workers and severely limits visibility. PMB will require a facility designed for the recovery and cleanup of media. The general technology for this type of facility already exists in permanent sandblasting facility operations which require only the addition of a recycling scheme for the plastic media.

The PMB process proved to be far less agressive than sandblasting. Some slight warping of the thin louvre plates on the first few shelters depainted. This was due primarily to inexperience on the part of the initial operators. When experienced PMB operators were used later in the demonstrations, warpage of the metal plates was not experienced. Reducing the pressure slightly and backing away from the substrate during blasting stopped the warping completely. PMB caused no delamination on the surface of the shelters. The thin metal panels and protective flaps, which had to be protected during both chemical stripping and sandblasting, were blasted unprotected and attached to the shelter. With proper PMB operation, the paint was removed from these panels with no adverse affects (e.g. warping and delamination). A

TABLE 19. CHEMICAL ANALYSIS OF SAND AND PMB CLEAN AND WASTE SAMPLES (mg/kg)

Parameters	Clean sand	Used sand	Clean PMB	PMB floor dust	Average PMB tunnel dust
Antimony	<0.2	2.4	<1	4	13
Arsenic	1.8	1	<1	<1	<1
Cadmium	<0.2	28	5	16	16
Chromium	7.4	240	5	72	120
Copper	3.8	6.6	2	4	4
Lead	1.2	160	<1	64	330
Mercury	<0.05	0.75	<0.01	<0.01	0.2
Nickel	5.2	8.6	37	81	30
Silver	<0.02	1.8	<1	<1	<1
Zinc	4.8	340	490	570	980

significant time savings can be realized by not having to remove and hand sand these panels. Open wiring, rubber gaskets, and latex seals, which had to be protected and replaced in both sandblasting and chemical stripping, were not affected by the PMB process. The Bakelite, a plastic used in the shelters, did not have to be masked or otherwise protected. The plastic media also removed CARC, a chemical-resistant paint now being used by the military, without difficulty from special test panels prepared for these evaluations. CARC was removed just as easily as enamel and lacquer. The water-based primer used with CARC was also easily removed. The surface finish was much smoother than the finish resulting from sandblasting, and there was no apparent metal loss. Finally, by cleaning down to the bare metal both inside and out, the PMB process allowed the QA/QC personnel to assess the condition of the shelter, and to readily detect areas needing repair and corrosion spot areas.

Because PMB can be used on thinner and softer substrates than sandblasting, there is no requirement to mark and hand sand exterior ventilation panels nor is there a requirement to hand sand the interior surfaces. These may be depainted by the PMB process during the normal depainting period. This labor savings for masking and hand sanding makes PMB economically competitive with sandblasting for depainting the military electronic communication shelters. An additional advantage to the PMB process is the quality of the surface finish of the substrate. By visual inspection there is no etching of the surface as with sandblasting and the surface looks like new metal. Paint pull tests conducted by facility QA personnel showed no apparent decrease in adhesion.

REFERENCES

1. Title 40 Code of Federal Regulations, Section 433 as amended by Federal Register Vol. 49, September 4, 1984, p. 34823.

2. Personal Communication with Casmalia Resources. November 26, 1985

3. Keane, J.N. ed., "Systems and Specifications" Vol. 2, 4th Ed. Steel Structures Painting Manual, Steel Structures Painting Council.

4. The Merck Index, 10th Ed. 1983. pg. 1043

5. "Coating Removal via Plastic Media Blasting," prepared by Materials Engineering Division, NAVAIR Engineering Support Office, Naval Air Rework Facility, Pensacola, Fl.

6. TB 43-0124 DOA Technical Bulletin "Maintenance and Repair Procedure for Shelters, Electrical Equipment."

7. Texas Air Control Board Compliance Sampling Manual Revised October 1975 Austin, Texas.

APPENDIX A

DIARY OF ACTIVITIES

TABLE A-1. SUMMARY FROM WORK RACK 658 LOGS (Equipment Depainted at Chemical Stripping Facility)

Date	Tag	Model	Tag order #
7/16	594	Shelter	248265
7/17	563	Shelter	247812
	211	Jack Plates	280995
	198	Panels	9052408
7/18	207	Shelter TTC-30	247810
	580	Pallet TTC-30	247811
	525	Transistor Panel GSH-35	7771496
	525	Cabinet/Door GSH-35	8771495
7/19	594	Shelter	9652144
7/22	204	Shelter RCA 35	9522404

PROJECT NO. 308028.40

PMB TESTING
CHEMICAL STRIPPING
JULY 24, 1985
ITEM NO. TSC60

Medium Size Communication Shelter # TSC60
Dimension 11 ft 6.5 in. (length) x 7 ft 3 in. (height) x 6 ft 8-3/4 in. (width) Enamel paint -- 3 layers of paint in camouflex pattern, possible primer MIL-P-23377
Paint stripper -- MIL-R-25134

First box came in partially masked. The timing of the work process started at moving of shelter.

Hour				
1050-1055	Moved shelter. Picked it up with a tractor and moved to the depaint work area. Placed shelter upon wooden blocks.			
1055-1100	Checked for openings and finished masking. Wiped shelter down. Temperature 34°C (sun); 29°C (shade)			
1100-1200	Lunch Break			
1209	Temperature Check	33°C (Sun) 34°C (Shade) 30°C (Person in suit in shade) 33°C (Person in suit in sun) 38°C (Person in suit in sun)		
1220	Spraying on depaint (stripper). Temperature 35°C at depaint work area.			
1221 hr	2:40 min	spray depaint	side 1 (left)	
1225 hr	1:43 min	spray depaint	back	
1227 hr	2:46 min	spray depaint	side 2 (right)	
1230 hr	1:24 min	spray depaint	front	
1231-1240	Allow depaint to set			
1241-1245	4:34 min	Scrub treated shelter with nylon brushes 2 people working (i.e., time x 2)		
1245-1259	Rinse depaint area. Water flowrate 23 lb/6 sec.			
1300-1309	Spray on depaint. 32°C temperature of person working in shade. Paint stripper flow rate 5.5 lb/60 sec.			
	1:04 min	spray depaint	top	
	2:01 min	spray depaint	side 1	
	1:01 min	spray depaint	back	

	2:41 min	spray depaint	side 2
	1:09 min	spray depaint	front

1309-1316 Allow depaint to set

1316-1324 7:58 min Scrub treated areas with wire brushes. 2 people working.

1324 ~1 min Rinse depaint area

1325-1415 Break

1415-1421 6:20 min 2 People brushing the top side only

1422-1425 ~2 min Spent rinsing the depaint area along with set-up to respray and depaint

1426-1432 Spray depaint on shelter. Temperature 32°C (shade metal surface) 37°C (sun)

0.58 sec	spray depaint	back
0.55 sec	spray depaint	side 2 (right)
0.46 sec	spray depaint	front
1.28 min	spray depaint	top
1.19 min	spray depaint	side 1 (left)

1431-44-1433:44 2 min Rinse off depaint area

1434-1441 7:57 min Brush or scrub down depaint area

1449-1505:13 Full rinse of shelter

~2:10 min	side 1 (left)	
~0:56 min	front	
~1:12 min	back	
~2:00 min	top	
~ -- min	side 2 (right)	

1510-1540 Break -- change of crew and set-up MEK scrub.

MEK - Bucket #1 -- 18.4 lb
Bucket #2 -- 9.4 lb
Bucket #3 -- 9.71 lb + 0.21 lb -- miss some of weight on 3rd bucket. 3 men work team; one man on harness for working on the roof.

1554- 2 men working
1556- All 3 men working (up to 8:44 min)

1602- 1 man working (2 men stop because of heat)
1603- 1 man working for 2:31 min

Reweight of #3 bucket 4.21 lb

1610- 1 man on roof/1 man stripping masking material/for 5:12 min

1615- All 3 men working. 1 on roof, other 2 scrubbing side 2 and front. 1:26 min.

1615:30- Water turned on low rinse
1616- Man on roof stops working. Other 2 men continue for ~2.5 min
Break
Reweigh of buckets #1 2.31 lb
#2 2.21 lb Tare = -4.41 lb
#3 2.41 lb

1649- End break and re-suit up. Refill buckets.
Bucket #1 3.2 lb
Bucket #2 -2.4 lb refilled 16.4 Tare = 0
Bucket #3 6.4 lb

1653- 1 man work alone 2:18 min
1655- 2 men working 1:31 min
1657- 3 men working 2:51 min
1700- 2 men working 1:56 min one man ran out of MEK refilled bucket #1 11.21 lb
1702- 3 men working 2:27 min
1704- 3 men working 1:08 min
1706- 2 men working 1:16 min
1708- 2 men working other person starts to spray with depaint front of the shelter while the other 2 work with MEK; total spray time is ~1 min. For 1:06 min, 1 man works alone.

1712- All 3 stop for break
1718- 1 man working on door (spray w/depaint) ~45 sec rinse down (increase flowrate of water) up to now water on constant low flowrate for continuous rinse.

1719- All 3 men working 1:29 min
1720- 2 men scrubbing, one man rinsing (self) 1:15 min
1722- 2 men working 1:32 min
1724- 1 man working 1:30 min
1726- Begin rinse down -- high pressure rinse 5:42 min

Re-weigh MEK buckets -- #2 or 3 3.31 lb Tare = 1.31 lb
#1 2.41 lb Tare = 2.01 lb

Rinse flowrate (at higher pressure) Tare = 2.11 lb
Flowrate 24.81 lb/10 sec
Slower flowrate (continuous rinse) 141 lb/sec

Large trailer being treated with depaint then rinsed with high-pressure hot water (54°C). Took 3.44 sec to rinse off a 94 in. x 172 in. section. Flowrate of H_2O was 1 barrel (55 gal) in 1 min 58 sec or 27.5 gal/min.

Dimension of entire van
7 ft 8-3/4 in. (height) x 8 ft (width) x 30 ft (length)

Started depaint morning of 7/24/85

WATER AND AIR SAMPLES

1230-1300	3 Draeger tubes samples 1st -- samples taken during 1st scrub down 2nd -- 2 samples taken during spray cycle
1352	Sump sample 1 VOK
1430	Draeger tube samples (2) taken in sun
1500	Sump sample 2 Effluent 1
1630	Effluent and sump samples (#4 and #5)

PROJECT NO. 308028.40

PMB TESTING
CHEMICAL STRIPPING
JULY 25, 1985
ITEM NO. TRC 97A

Hour	
1021:00	Start of taping of small (6x6) communication shelter (partially taped upon arrival)
1028:19	Begin wipe down
1032:37	A.M. temperature 23°C (calibrate ice cup -2°C)
1048:50	Stop taping (unit 850183 -- total taping time for remaining panels i.e., door, door panel, rear panels.)
1100:00	Surface temperature 25°C (strong breeze)
1105:03	Start of spraying of stripper -- overhang
1106:10-1108:47	Roof
1108:58-1110:24	Right side
1110:40-1112:10	Front
1112:49-1114:28	Back
1114:29-1116:09	Left side
1120:00	Water off
	Water on continuous low rinse entire time. Flowrate of spray 3.31 lb/30 sec bucket tared out. Break.
1220:00	End of break. Wait time of ~1 hr. Paint not very affected by depaint. The air is cooler (23°C) and humidity higher. Wind 10-25 mph.
1219:03	Started scrubbing roof with wire brush
1223:44	Started scrubbing right side

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1225:05- 1225:36	Rinse hose on
1226:01- 1228:14	1 person scrubbing the back; another person scrubbing the front
1228:15- 1229:49	2 people scrubbing the left side
1229:50- 1229:56	One person scrubbing
1229:57- 1230:27	Water rinse
1233:24	Spraying on depaint (application rate varies as it is manually controlled). Spray is 76 psi at the compression.
1233:32	Rinse water on
1235:00	Begin 2nd spraying of depaint. 2nd application appears to go on under more pressure than the 1st.
1235:00- 1236:18	Roof
1236:31- 1237:34	Back
1237:36- 1238:20	Side 1 (right)
1238:39- 1239:28	Front
1239:36- 1240:33	Side 2 (left)
1241:37	Rinse water off
1239:36	Set time and break
1309:16- 1310:10	Rinse water; pressure reduced to low flow rinse rate at 1310:10
1310:14	MEK Scrub MEK #1 16.31 lb MEK #2 15.1 lb

1310:14- 1313:31	1 man scrubbing
1314:28- 1319:15	Scrub with tooth brush
1319:40- 1322:36	Change to a wire brush
1322:37- 1325:40	2 men scrubbing
1326:16- 1327:11	Spray on more depaint; also increase pressure of rinse water
1327:40- 1327:57	1 man scrubbing alone
1327:57	2 men scrubbing
1329:45	1 person move to the right side
1330:30	Both people move to the front Water turned off
1335:38	Stop scrubbing
1336:00- 1336:51	Spray front
1336:30- 1339:51	Water on high pressure rinse
1337:15- 1338:13	Spray right side
1338:18- 1339:21	Spray back
1341:25- 1347:40	Scrub with MEK, 1 person using a wire brush Left side, area cleaned 28 in. x 50 in.
1334:45	Put water on low pressure
	Re-weigh of MEK: MEK #1 -- 12.8 lb before 2nd application MEK #2 -- 12.1 lb

1431:25- 1434:30	Brushing with MEK, 1 person using wire brush, left side
1435:30- 1436:35	Left side
1436:- 1437:14	Front
1437:15- 1438:32	Right
1438:33- 1439:43	Back
1440:04- 1440:50	Top
1444:15- 1451:36	Water pressure changed from low to high
	Re-weight of MEK buckets: MEK #1 12.2 lb MEK #2 11.8 lb
	Break -- end of 1st shift
	Using stronger stripper with phenols called 3500, MIL spec -- 8010010230343
1605:00- 1616:30	Strong rinse (high pressure)
1619:00- 1623:15	1 man scrub with MEK
1623:45- 1624:20	1 man scrub with MEK
1624:55- 1625:26	1 man scrub with MEK
	At start of scrub the bucket weighed 19.5 lb; end of scrub, bucket weighed 8.4 lb
1619-1620	Removing tape covering door, etc.
1629:03- 1631:09	Spraying with new stripper (phenolic) Water on same slow rinse since beginning

1634:30-1634:11	Rinse
1634:12-1637:23	Increase of water pressure
	Break to let stripper set
1708:37-1709:04	2 men scrubbing
1709:05-1713:59	3 men scrubbing
1714:00-1714:46	2 men scrubbing
1714:47-1715:15	1 man scrubbing alone
1715:20-1718:45	Spraying phenolic stripper
1719:20-1719:40	Spraying phenolic stripper
1721:31	Water was put on low rinse at the start of spraying and stopped at break
1754:54-1755:04	1 man scrubbing the phenolic stripper off
1755:05-1755:31	2 men scrubbing the phenolic stripper off
1755:32-1806:39	3 men scrubbing the phenolic stripper off
1759:39	Notice water running at rinse level, probably turned on at beginning of scrubbing
1807:40-1808:42	1 man scrubbing alone
1808:10-1817:17	Strong rinse

STOP

SAMPLES TAKEN

Charcoal tube
5 samples taken between 1100-1112
Draeger tubes ~50 ppm

1st personal charcoal tube taken at 1220 at re-start.
Also personal samples taken on operator: one for scraping
two for spraying

Before start, ~10 min of taping. Estimate of personnel is that about 30 min would be needed for full taping.

0846:07- 0847:23	Water strong rinse, (i.e., high pressure)
0854:16- 0856:39	Begin spraying depaint, start with front of shelter
0856:46- 0858:33	Spray side 1 (left)
0900:30	Water turned off
	Break of about 30 min, after break noticed that the paint was falling off in patches
0932:49- 0934:58	Return to spraying depaint, start with back or end of shelter
0935:15- 0939:30	Side 2 (right)
0940:10- 0942:32	Side 1 (left) 2nd application
0941:16- 0942:15	Front
	Break
0944:49- 9045:30	Measured depaint flowrate. Tare of bucket 1.41 lb. Final wt = 8.1 lb
1019:59- 1021:38	Begin scrubbing shelter and depaint with a wire brush
1022:10- 1022:56	Scrubbing roof
1022:46	Water on strong rinse
1024:38- 1026:06	Continue scrubbing roof

1026:28-1027:40	Continue scrubbing roof
1025:46-1027:39	2nd man begin scrubbing front of shelter
1027:40-1031:42	Side 2 (right) 1 person
1027:54-1029:17	Side 1 (left) 2nd person
1029:22-1031:29	Back 1 person
1033:47-1037:41	Return to spraying -- start with the roof
1034:00-1048:58	Water tuned on, slow rinse pressure level
1038:12-1039:45	Spraying the front
1039:46-1041:33	Left side
1041:40-1043:07	Back
1043:15-1046:42	Right side
	Break to allow depaint to set -- lunch
1227:31-1248:30	Rinse off shelter with hot water, high-pressure hose
1248:31-1250:30	Change pressure to a finer spray. Also on at about the same time, regular hose was on at a higher pressure for rinse of depaint area and some removal of paint.
1245:17	Regular (or lower pressure) hose turned off
1250:30-1253:25	Regular hose rinsing depaint area

Note:	The shelter had walk way coat on the roof, which makes it more difficult to remove; the coating was about 15 mL thick with a coat of paint covering it. Walk way coating is usually tar or petroleum based and mixed with sand.
1321:55	Water on slow rinse to wet down depaint area
1323:58	Spraying on depaint, total time = 9 min 42 sec
1342:10- 1342:40	Turn regular rinse hose up to high pressure to rinse area.
1343:00- 1345:04	Begin brushing with MEK, bucket at start = 13.6 lb, 1 man brushing.
1345:05- 1349:29	2 men brushing or scrubbing shelter, only 1 person using MEK
1349:30- 1349:49	1 person brushing and using MEK
1349:50- 1352:44	2nd man return and both work with toothbrush and MEK
1352:45- 1353:29	1 man working alone
1353:30- 1354:29	2 men working
1354:30- 1355:05	Last man works alone
1355:50- 1402:21	Using high-pressure hose to rinse
1355:50- 1402:51	Using 2 regular hoses with pressure up high to rinse
	Break
1429:04- 1432:03	Remove tape from door etc.
1432:00- 1436:52	Spraying depaint on areas that the tape covered. Total actual spray time = 2 min 40 sec.

1438:40-1439:27	Begin scrubbing with MEK, 1 man using toothbrush
1439:28-1442:39	2 men scrubbing using toothbrushes, one using MEK
1442:40	1 man continues to scrub, the other stops to spray depaint
1442:50-1443:17	Spraying depaint
1443:38-1444:30	Spraying depaint
1445:00-1445:44	2 men scrubbing using toothbrushes and MEK
1445:45-1447:10	1 man scrubbing using toothbrush and MEK
1447:43-1448:18	1 man scrubbing using toothbrush and MEK
1448:19-1449:55	2 men scrubbing using toothbrushes and MEK
1450:00	Spray depaint for about 1 min. 1 man continuing to scrub.
1451:21-1458:19	Back to 2 men scrubbing
1458:20-1502:00	1 man scrubbing
1501:38-1512:30	Begin rinsing both shelter and depaint area with high pressure hose.
1508:38-1510:06	1 man scrubbing
1512:30	End all activity, shelter finished
	Re-weigh MEK bucket 13.2 lb
Note:	For small parts, hot tank stripper is MIL-R-83936B

SANDBLASTING LOG

H. VOL
CHARCOAL TUBE
GRAB SOLIDS

10/21/85 -- Meeting for Sandblasting
10/22/85 -- Identification of shelter to be used for sandblasting

1) #788 -- GRC-142
2) #870 -- GRC-142
3) #490 -- GRC-142
4) #T68-009-97 -- TRC-117
5) #T68-009-45 -- TRC-117
6) #05 -- TRC-117

Shelters were then measured and inspected by the QA/QC personnel of SAAD.

PMB TESTING
SANDBLASTING
OCTOBER 23, 1985

Timing of paint removal began at the commencement of blasting. For each blasting sequence two shelters, were blasted simultaneously.

Sand Type -- Clementina 0/30 (#30 mesh).

Prior to 0930 -- shelters were moved into the blasting booth.

SHELTER #870
Small-size communication shelter
Dimensions: 6.1 ft (length) by 7.6 ft (height) by 6 ft (width)

Hour	
0930:15-0933:11	Left side
0933:11-0940:02	Door
0940:02-0943:39	Right side
0944:00-0947:05	Back
0947:10-0947:50	Flip shelter to blast both bottom and roof
0949:00-0952:50	Roof
0953:00-0954:44	Bottom (right overhang)
0954:44-0957:00	Stop to load sand (put in 4 bags at 100 lb/bag)
0957:00-0958:47	Actual bottom of shelter
0958:47-1000:31	Left overhang

1000:31-1001:00 Re-right the shelter

SHELTER #788
Small size communication shelter
Dimensions: 6.1 ft (length) by 7.6 ft (height) by 6 ft (width)

Hour	
0930:00-0933:26	Back
0933:30-0937:23	Right side
0937:23-0940:55	Front
0940:55-0945:00	Left side
0945:00-0947:00	Flip shelter to blast both bottom and roof
0947:00-0948:15	Right overhang
0948:15-0950:15	Actual bottom
0950:15-0952:15	Left overhang
0952:30-0953:43	Top
0953:43-0956:50	Stop to load sand (put in 4 bags at 100 lb/bag)
0956:55-0959:56	Finish top
1000:31-1001:00	Re-right shelter

1001:00-1014:00 Clean up area by blowing sand into waste sand bin

1014:00-1037:00 Move first set of shelters from the blasting booth and move second set of shelters into the blasting booth

SHELTER #T68-699-097
Medium-size communication shelter
Dimensions: 11.6 ft (length) by 6.5 ft (height) by 6 ft (width)

Hour	
1037:30-1047:00	Left side
1047:00-1052:27	Back
1052:27-1102:55	Right side
1103:10-1104:25	Front
1112:05-1118:25	Front

SHELTER #490
Small-size communication shelter; was painted in a camouflage pattern
Dimensions: 6.1 ft (length) by 7.6 ft (height) by 6 ft (width)

Hour	
1037:00-1047:00	Left side
1047:00-1101:16	Front
1101:17-1118:44	Right side (1 man only)

At this point in time, the second person blasting had finished his shelter and began assisting the person blasting this shelter.

1118:44-1121:55	Continue right (1 person each)
1118:44-1121:55	Back (1 person each)
1122:00-1124:00	Flip shelter to blast both bottom and roof
1124:00-1126:49	Left overhang (1 person only)
1126:49-1131:16	Bottom (1 person only)
1124:00-1131:05	Right overhang (1 person only)
1131:06-1132:03	Roof (2 people working on same area)
1131:03-1246:00	Stop to load sand; move second set of shelters out and third set of shelters into the blasting booth
	Lunch

SHELTER #05
Medium-size communication shelter
Dimensions: 11.6 ft (length) by 6.5 ft (height) by 6 ft (width)

Hour	
1247:05-1253:40	Left side
1253:45-1259:20	Back

Hour	
1259:20-1306:34	Right
1306:55-1312:00	Front

SHELTER #T68-097-45
Medium-size communication shelter; painted in a camouflage pattern
Dimensions: 11.6 ft (length) by 6.5 ft (height) by 6 ft (width)

Hour	
1246:00-1259:30	Back
1300:00-1311:13	Left side (1 man only)
1311:13-1313:05	left side (1 man only)
1311:13-1313:05	Front (1 man only)
1313:05-1315:39	Stop to load sand
1316:12-1324:06	Left side (2 men blasting)
1316:00-1319:12	Front (1 man only)
1324:06-1333:28	Right side (2 men blasting)
1333:28-1335:47	Stop to load sand
1335:47-1338:45	Front (1 person only)
1338:45-1351:47	Cleanup

PMB TESTING
HANDSANDING OBSERVATIONS
OCTOBER 23, 1985

Day 1

- Observed the partial handsanding of a GRC-142 shelter

Start 1034

- Exterior of shelter
  - -- Thin panels, that are not sandblasted, are removed, handsanded, and replaced: 4:42:25 min, 18.25" x 12.25" dimension
- Inside panel: 2726 cm^2 (0.28 m^2), 3:16:03 min to sand
- Right wall: 1.78 m^2, 26:00 min
- Left wall: 2.02 m^2, 22.42 min

Stop

Begin 1303

- Back
  - -- Section 1: 0.559 m^2, 12:40 min
  - -- Section 2: 1.56 m^2, 21:33 min
- Vacuum up of dust: 6 min
- Left bench: did a 97.5 cm x 370.5 cm rectangle (3.612 m^2), took 9:29 min

Day 2

- Observed the partial handsanding of a GRC-142 shelter

Start 0954

- Bench: 452.56 cm x 94.25 cm (0.652 m^2), took 12:30 min
- Back wall 5:29 min for small rectangle back wall

Stop

Flips shelter

Start 1120

- Front door, 3:47 min
- Left wall (1.861 m^2), 16:06 min
- Back wall for 2:00
- Raised structure on back wall 4:21 min
- Back wall for 2:52 min

Stop

10/22/85 -- Identification of shelter to be used for PMB

1) #T68-340-10 Large
2) #1132 Small
3) #138 Small
4) #139 Large
5) #0329A Small

Shelters were then measured and inspected by the QA/QC personnel of SAAD.

PMB Pressure 30 psi

Shelter 1 -- Serial #T68-340-10

Throttle for open blaster -- one-fourth open

Blasting time -- closed blaster, inside side panel, sample section (3 ft x 3 ft) (rt)

Start	0:00	29:30
Stop	23:50	39:45

Total 34:05

95 percent blasted to bare metal/5 percent to primer

Floor panel, sample section (3 ft x 3 ft)

Start	0:00
Stop	7:30

Blasting time -- open blaster, outside, Right side panel

Start	0:00	9:00	25:45	47:30	59:30	1:08:30
Stop	7:00*	24:50*	32:30**	58:30**	107:30	1:20:30

Total 1:40:15

Left side panel

Start	0:00	6:45	16:15	18:45	30:30
Stop	5:30**	13:45**	17:15*	29:15	34:30
Start	37:45	41:15	44:30	0:00	11:30
Stop	39:45	43:00	47:30	7:00	28:15
Start	31:00	42:00			
Stop	40:30	47:00			

Total 1:12:00

---

*Stop to reload
**Fixed blaster

Inside right wall

Start	0:00	39:00	49:00	1:00	4:15
Stop	10:00	48:30	53:00	3:00	7:00
Start	31:00	35:30	53:45		
Stop	35:00	48:00	54:00		
Start	1:03:30	1:35:15			
Stop	1:08:30	1:43:30			

Total 58:15

Inside door

Start	7:45	0:00	11:30
Stop	11:45	6:00	17:15
Net	4:00	6:00	5:45

Total 15:45

Back side

Start	9:00	1:25:00	1:32:45
Stop	13:00	1:30:00	1:41:15
Net	4:00	5:00	8:30

Total 17:30

Shelter 1 -- October 30, 1985

Back wall, inside

Start	0:30	34:00
Stop	24:00*	44:00

Total 33:30

Top side, outside

Start	0:00	12:00	16:30	20:00	31:00
Stop	10:00	15:30	18:30	30:00	34:45

Total 29:15

---

*Stop to reload

Left side, inside

Start	44:15	1:08:30	0:00	16:00	2:45
Stop	53:00	1:15:00	14:30	18:15	8:45

Total 38:00

Front side, outside

Start	1:01:30	1:06:15	7:30	25:00	30:45
Stop	1:04:45	1:06:30	16:00	30:15	36:00

Total 22:30

Ceiling, inside

Start	--	10:45	38:00	40:00	58:00
Stop	--	26:00	39:00	53:00	1:22:00
Net	12:00	15:15	1:00	13:00	24:00

Total 65:15

Floor, inside

Start	0:30	26:00	1:28:00	--	--	--	--
Stop	19:30	27:30	1:35:00	--	--	--	--
Net	19:00	1:30	7:00	3:00:00	20:00*	15:00	45:00

Total 4:47:30

*New hose (~3/2 in. I.D.)

Shelter completed 23:30

Outside:		Inside:	
Front	22:30	Front	15:45
Left side	1:12:00	Left side	38:00
Right side	1:40:15	Right side	58:15
Back	17:30	Back	33:30
Top	29:15	Ceiling	1:05:15
		Floor	4:47:30
Total	4:01:30		
		Total	8:18:15

Total time to blast Shelter 1: 12:19:45

Solids and water samples taken before blasting Shelter 2

Shelter 2 -- Serial #1131, size: small

Left wall, outside

Start 0:00 (10:35:30)
Stop 17:15, completed

Now reloading; worked on chair

Left wall, underside, outside

Start 22:30
Stop 28:30, completed, reloading
Total 6:00, at 34 min, problem with unit

Back side, outside

Start 52:00
Stop 1:13:30
Total 21:30

Front side, outside, inside of hatch

Start 1:16:30
Stop 1:51:00, completed
Total 34:30

Top side, outside

Start 0:00 (1:43:30) 11:15
Stop 5:45 38:00
Total 32:30

Stop for reloading

Right side, outside

Start 44:00
Stop 1:05:30
Total 21:30

Right side, underside, outside

Start 1:07:00
Stop 1:18:00
Total 11:00

Total of right side: 32:30

Back wall, inside

Start	35:45	57:30	1:07:00	1:09:15
Stop	49:00	1:03:00	1:08:15	1:12:00
Net	13:15	5:30	1:15	2:45

Total 22:45

Left wall, inside

Start	1:20:30	1:33:45	1:38:15
Stop	1:31:00	1:36:00	1:42:30
Net	10:30	2:15	4:15

Total 17:00

Right wall, inside

Start	1:42:30	1:53:00
Stop	1:47:00	2:02:45
Net	4:30	9:45

Total 14:15

Front wall, inside excluding door

Start	2:03:00
Stop	2:06:30
Net	3:30

Ceiling, inside

Start	2:09:30
Stop	2:22:30
Net	13:00

Floor

Start	2:28:00	2:33:45
Stop	2:32:45	2:34:30
Net	4:45	:45

Total 5:30

Note: Floor was about half bare to begin with.

Inside door

Start	2:34:30	2:42:15
Stop	2:35:45	2:46:15
Net	1:15	4:00
Total	5:15	

Outside:

Front	34:30
Left side	23:15
Right side	32:30
Back	21:30
Top	32:30
Total	2:24:15

Inside:

Front	8:45
Left side	17:00
Right side	14:15
Back	22:45
Ceiling	13:00
Floor	5:30
Total	1:21:15

Total time to blast Shelter 2: 3:45:30

Shelter 3 -- No. 138

Size: Small

Ceiling, inside

Start	0:30
Stop	20:00
Net	19:30

Left wall, inside

Start	30:00	41:30	1:03:45
Stop	37:00	46:45	1:13:00
Net	7:00	5:15	9:15

Total: 21:30

Right wall, inside

Start	1:19:00	1:42:30	1:56:30	2:03:00
Stop	1:31:30	1:44:00	2:00:15	2:11:30
Net	12:30	1:30	3:45	8:30

Total: 26:15

Reloading, Lunch

Back side, outside

Start	7:30	54:00
Stop	9:00	1:02:30
Net	1:30	8:30

Total: 10:00

Back wall, inside

Start	1:12:00	1:21:45
Stop	1:18:15	1:32:45
Net	6:15	11:00

Total: 17:15

Shelter 3 -- Continued

Left outside wall

Start	1:26:45	1:38:00
Stop	1:36:30	1:40:00
Net	9:45	2:00

Total: 11:45

Reloading/cleaning out

Left underside, outside

Start	1:43:45	1:47:00	1:51:45
Stop	1:46:00	1:47:30	1:54:00
Net	2:15	0:30	2:15

Total: 5:00

Floor

Start	1:42:45	1:57:15	2:02:45
Stop	1:48:15	1:58:30	2:05:15
Net	5:30	1:15	2:30

Total: 9:15

Top side, outside

Start	1:58:30	2:02:30	1:45	
Stop	2:01:00	2:03:45	8:30	completed
Net	2:30	1:15	6:45	

Total: 10:30

Front wall, inside excluding door

Start	0:00
Stop	7:00
Net/Total	7:00

Shelter 3 -- Continued

Right wall, outside

Start	11:30	34:00
Stop	18:45	36:00
Net	7:15	2:00

Total: 9:15

Right wall underside, outside

Start	48:00
Stop	53:00 completed

Total: 5:00

Front side, outside plus inside door

Start	1:06:15	1:08:15	1:17:00	1:22:00
Stop	1:07:15	1:08:45	1:21:15	1:32:45
Net	1:00	0:30	4:15	10:45

Total: 16:30

Shelter 3 -- Time to Complete

Outside

Front and inside door	16:30
Left side	16:45
Right side	14:15
Back	10:00
Top side	10:30
Total time to blast outside	1:08:00

Inside

Front, excluding door	7:00
Left side	21:30
Right side	26:15
Back	17:15
Ceiling	19:30
Floor	9:15
Total time to blast indoor	1:40:45

Total blast time 2:48:45

Shelter 4 -- No. 139
No ambient testing
Camouflage painted unit
Only Clemco pot will be used

Back side, outside

Start	0:00 (10:17)	
Stop	18:30	completed
Net/Total	18:30	

Left side, outside

Start	19:00	
Stop	41:30	completed
Net/Total	22:30	

Front side, outside and inside of door

Start	42:15	53:15+*	58:45	
Stop	53:15	58:45	1:15:45	completed
Net	11:00	5:30	17:00	
Total	33:30			

Right side, outside

Start	1:16:30	1:22:00	
Stop	1:21:15	1:45:30	completed
Net	4:45	23:30	
Total	28:15		

Stop to move pot

Top side, outside

Start	0:00 (14:03)	
Stop	30:45	
Net/Total	30:45	

Back wall, inside

Start	32:00	
Stop	39:15	
Net/Total	7:15	

*Media no long fresh
+Inside Door

Shelter 4 -- Continued

Right wall, inside

Start	39:45	
Stop	1:05:45	completed
Total	26:00	

Left wall, inside

Start	1:06:15	
Stop	1:37:30	
Net/Total	31:15	

Ceiling

Start	1:38:00	2:04:00	
Stop	2:02:00	2:23:00	
Net	24:00	19:00	completed
Total	43:00		

Reload

Front wall excluding door, inside

Start	2:23:00	
Stop	2:32:15	
Net/Total	9:15	

Floor

Start	2:39:45	
Stop	3:04:00	completed
Net/Total	24:15	

Shelter 4 -- Times to Complete

Outside

Front and inside of door (5:30)	33:30
Left side	22:30
Right side	28:15
Back	18:30
Top	30:45
Total time to blast outside	2:13:30

Inside

Front excluding inside of door	9:15
Left side	31:15
Right side	26:00
Back	7:15
Ceiling	43:00
Floor	24:15
Total time to blast inside	2:21:00

Total blast time	4:34:30

Shelter 5 -- 0329A

Small shelter
No ambient samples taken
Try to go only to primer

Floor (note: floor was about 60 percent bare metal)

Start	0:00
Stop	9:00
Net	9:00

Back wall, inside

Start	11:00
Stop	20:45 completed
Net	9:45

Left wall, inside

Start	21:00
Stop	28:30
Net	7:30

Right wall, inside

Start	29:15	34:45
Stop	32:15	40:15
Net	3:00	5:30

Total: 8:30

Reload

Ceiling

Start	40:45
Stop	48:30
Net	7:45 completed

Front wall, inside excluding doors

Start	48:45
Stop	53:30
Net	4:45

Shelter 5 -- Continued

Back side, outside

Start	56:30	1:10:15
Stop	1:07:30	1:13:30
Net	11:00	3:15

Total: 14:15

Reload

Left side, outside

Start	1:13:30
Stop	1:27:30
Net	14:00

Left underside, outside

Start	1:27:30	1:31:30
Stop	1:29:00	1:35:30
Net	1:30	4:00

Total: 5:30

Right underside, outside

Start	1:36:30	1:42:15
Stop	1:40:30	1:43:15
Net	4:00	1:00

Total: 5:00

Reload

Right side, outside

Start	1:43:30	1:54:00
Stop	1:52:30	2:03:30
Net	9:00	9:30

Total: 18:30

Reload

Shelter 5 -- Continued:

Top side, outside

Start	2:04:30	2:07:30
Stop	2:06:30	2:29:45
Net	2:00	22:15

Total: 24:15

Reload

Front side, outside

Start	2:30:45	2:38:00	2:42:00
Stop	2:37:15	2:42:00	3:03:00
Net	6:30	4:00	21:00

Total: 31:30

Times to Complete

Outside

Front plus inside of door (4:00)	31:30
Left side	19:30
Right side	23:30
Back	14:15
Top	24:15
Total time to blast outside	1:53:00

Inside

Front	4:45
Left side	7:30
Right side	8:30
Back	9:45
Ceiling	7:45
Floor	9:00
Total time to blast inside	47:15

Total time to blast shelter 2:40:15

TABLE A-2. PMB TESTING -- WEEK OF NOVEMBER 1, 1985

Shelter number	1	2	3	4	5
Serial number	T68-340-10	1132	138	139	0329A
Outside					
Front	22:30	34:30	16:30[a]	33:30[a]	31:30[a]
Left side	1:12:00	23:15	16:45	22:30	19:30
Right side	1:40:15	32:30	14:15	28:15	23:30
Back	17:30	21:30	10:00	8:30	14:15
Top	29:15	32:30	11:00	30:45	24:15
Total outside	4:01:30	2:24:15	1:08:00	2:13:30	1:53:00
Inside					
Front	15:45	8:45	7:00[b]	4:15[b]	4:45[b]
Left side	38:00	17:00	21:30	31:15	7:30
Right side	58:15	14:15	26:15	26:00	8:30
Back	33:30	22:45	17:15	7:15	9:45
Ceiling	1:05:15	13:00	19:30	43:00	7:45
Floor	4:47:30	5:30	9:15	24:15	9:00
Total inside	8:18:15	1:21:15	1:40:45	2:21:00	47:15
Total time to complete	12:19:45	3:45:30	2:48:45	4:34:30	2:40:15
Shelter size	Medium	Small	Small	Medium	Small

[a]Includes inside of front door.
[b]Excludes inside of front door.

Note: hours: minutes: seconds.

APPENDIX B

CHEMICAL ANALYSES

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Centers for Disease Control
National Institute for
Occupational Safety & Health
Robert A. Taft Laboratories
4676 Columbia Parkway
Cincinnati OH 45226

September 30, 1985

Ms. Cameron McDonald
Acurex Corp.
555 Clyde Ave.
Mountain View, CA 94039

Dear Ms. McDonald:

The attached tables summarize the data Dr. Gideon and I collected at McClellan Air Force Base in Sacramento, California. The charcoal tubes were analyzed for methylene chloride according to NIOSH method 1005. Methylene chloride was not detected on the back-up charcoal tubes. Methylene chloride was not detected on 15 of 16 field blanks. Although 0.07 mg of methylene chloride was found on one field blank, it was ignored. The bulk liquid samples were analyzed according to NIOSH method P&CAM 127. The pages of the analytical report which describes the details of the analysis are attached.

If you have any questions about these results, do not hesitate to contact me at 513/841-4221.

Sincerely yours,

William A. Heitbrink

William A. Heitbrink
Research Chemical Engineer
Mining and Minerals Section
Engineering Control Technology Branch
Division of Physical Sciences and
Engineering

Enclosures (5 pages)

TABLE B-1. METHYLENE CHLORIDE CONCENTRATIONS MEASURED WITH DRAEGER DETECTOR TUBES

Date	Time	Description of activity	Concentration (ppm)
7/24	PM	Scraping paint from shelter	50
		Break during scraping activity	0-10
		1-2 ft from shelter while spraying surface with depaint solution	400
		1-2 ft from shelter while spraying surface with depaint solution	700
7/25	11:00	Spraying shelter with depainting solution	50
	11:15	Workers using wire brush to clean surface	150
	12:30	Spraying shelter with depainting solution	75

TABLE B-2. METHYLENE CHLORIDE CONCENTRATIONS MEASURED WITH CHARCOAL TUBES

Date	Time	Description of activity	Concentration (ppm)
7/25	11:00-11:12	10 ft down wind of module	12
		10 ft from module, on a line normal to wind direction	45
		Near video camera	lod
		Worker spraying depaint on shelter	51
7/25	12:19-12:30	worker scrubbing shelter with wire brush	84
7/25	12:30-12:35	Worker spraying depaint on shelter	138
7/25	16:27-16:32	Worker spraying depaint on shelter	7
7/25	evening shift	Cameron (away from operation)	lod
		Jim, scraping off paint	lod
		Harlan, scraping off paint	42
		Bill, scraping off paint	lod
7/26	8:49-8:59	Worker spraying depaint on shelter	68
	10:20-10:30	Worker scraping paint from shelter	92
	10:35-10:45	Worker spraying on depaint	249
		Worker spraying depaint on shelter	192
	12:25-12:50	Worker washing down shelter	58
		Worker washing down shelter	33

lod -- limit of detection: 0.01 mg/sample. For a 1 liter air sample, the limit of detection is 3 ppm.

TABLE B-3. CONCENTRATION OF METHYLENE CHLORIDE IN BULK WATER SAMPLES

Date	Time	Description of activity	Concentration mg/mL
7/24		Sump (phenol concentration was 0.06 mg/mL)	1.9
7/24	15:00	Effluent during hot water wash	4.6
7/24	16:30	Effluent during hot water wash	0.9
7/24	16:30	Sump	1.4
7/25	13:30	Sump	0.27
7/26		Sump	0.78
7/24	15:00	Sump (sample bottle leaked during shipment)	

Note: The limit of detection for phenol and methylene chloride was 0.01 mg/mL. With the exception of the first sample on 7/24, phenol was not detected in the water samples.

Re: Seq. 5020-J
Gas Chromatography

ANALYTICAL REPORT

SUBMITTED TO:	W. Heitbrink
SUBMITTED BY:	Sue Norbury
REFERENCE DATA:	
Analysis of:	Methylene Chloride
Project Identification	
Sequence No.	5020-J
Sample(s): 64	Analyses: 64
UBTL Laboratory No.:	85-7197 through 85-7260

The A and B sections of the above numbered charcoal tube samples were separated and analyzed by gas chromatography according to NIOSH Method 1005 with modifications.

Desorption Process:	30 minutes in 1.0 milliliter of carbon disulfide containing 1 microliter/milliliter of hexane as an internal standard
Gas Chromatograph:	Hewlett-Packard Model 5711A equipped with a flame ionization detector
Column:	30m x 0.32 mm fused silica capillary coated internally with 0.5 µm of DBWAX
Oven Conditions:	40°C, isothermal

Standards were spiked onto the A sections of charcoal tubes and desorbed the same as the samples.

The limit of detection was 0.01 milligram/sample for methylene chloride.

The reported values have not been field blank corrected.

Re: Seq. 5020-K
Gas Chromatography

ANALYTICAL REPORT

SUBMITTED TO: W. Heitbrink

SUBMITTED BY: Sue Norbury

REFERENCE DATA:

Analysis of:	Methylene Chloride and Phenol
Project Identification	85-404
Sequence No.	5020-J
Sample(s): 6	Analyses: 12
UBTL Laboratory No.:	85-7427 through 85-7432

The above numbered bulk samples were analyzed by gas chromatography according to NIOSH Method P&CAM 127 with modifications.

Analytical Process:	Direct injection of 1.0 milliliter aliquots of the samples
Gas Chromatograph:	Hewlett-Packard Model 5830A equipped with a flame ionization detector
Column:	30m x 0.32 mm fused silica capillary coated internally with 1.0 µm of DB-5
Oven Conditions:	Thermal programming 35°C to 150°C at a rate of 8°C/min

The limit of detection was 0.01 milligram/sample for methylene chloride and phenol.

The reported values have not been field blank corrected.

TABLE B-4. LIST OF SAMPLES TAKEN

Sample	Material	Source
904121	Sand	Clean
904173	Sand	Baghouse burner
905305	Plastic media	Clean
905304	Plastic media	Floor sample
905306	Plastic media	Floor sample
905303	Plastic media	Filter dust
810995	Water	Portable recovery system
810996	Water	Portable recovery system
810997	Water	Portable recovery system

ACUREX Corporation

Energy & Environmental Division

February 11, 1986
Acurex ID No. 8601-010
Client No. 308033
Page 1 of 3

Acurex Corporation

Attention: Dean Wolbach

Subject: PMB samples (received 1/7/86)

The above samples were analyzed for the 13 priority pollutant metals by digestion with nitric acid followed by atomic absorption spectrophotometry. Total organic carbon of water was determined by the persulfate-ultraviolet oxidation Method 5058 of Standard Methods for the Examination of Water and Wastewater, 16th edition. Percent carbon and percent hydrogen determinations of sand and plastic media were provided by Galbraith Laboratories.

Results of sand and plastic media analyses are provided in Table 1. The method blank for these samples did not have detectable levels of any of the priority pollutant metals.

Results of water analyses are provided in Table 2. The method blanks for priority pollutant metals and total organic carbon did not have detectable levels of any of the parameters.

Prepared by: Patrick M. Hirata
Patrick M. Hirata
Staff Chemist

Approved by: Greg Nicoll
Greg Nicoll
Manager, Inorganic Chemistry

555 Clyde Avenue, P.O. Box 7555, Mountain View, CA 94039 (415) 964-3200 Telex: 34-6391 TWX: 910-7796593

TABLE B-5. CONCENTRATION, MG/KG

	Sand			Plastic					
Parameter	904173	904121	dL	905304	905305	905306	905302	905303	dL
Antimony	2.4	<0.2	0.2	<1	<1	4	<1	13	1
Arsenic	1.0	1.8	0.2	<1	<1	<1	<1	<1	1
Beryllium	<0.2	<0.2	0.2	<1	<1	<1	<1	<1	1
Cadmium	28	<0.2	0.2	4	4	5	16	24	1
Chromium	240	7.4	0.2	49	5	72	27	120	1
Copper	6.6	3.8	0.2	4	2	4	5	4	1
Lead	160	1.2	0.2	37	<1	64	71	330	1
Mercury	0.75	<0.05	0.05	<0.1	<0.1	<0.1	<0.1	0.2	0.1
Nickel	8.6	5.2	0.4	81	37	50	78	30	2
Selenium	<0.2	<0.2	0.2	<1	<1	<1	2	<1	1
Silver	1.8	<0.2	0.2	<1	<1	<1	<1	<1	1
Thallium	<0.2	<0.2	0.2	<1	<1	<1	<1	<1	1
Zinc	340	4.8	0.2	370	490	570	310	980	1
Percent Carbon	0.72	0.10	--	35.22	35.34	34.98	37.16	34.48	--
Percent Hydrogen	0.11	0.04	--	5.42	5.59	5.37	5.68	5.49	--

TABLE B-6. CONCENTRATION, MG/L

	Water			
Parameter	810996	810997	810995	dL
Antimony	0.27	0.35	0.32	0.01
Arsenic	<0.01	<0.01	<0.01	0.01
Beryllium	<0.01	<0.01	<0.01	0.01
Cadmium	3.0	4.5	7.4	0.01
Chromium	36	89	82	0.1
Copper	0.61	0.64	1.3	0.01
Lead	17	17	6.1	0.01
Mercury	<0.001	<0.001	<0.001	0.001
Nickel	0.19	0.30	0.52	0.02
Selenium	0.02	0.03	0.03	0.01
Silver	0.03	0.04	0.02	0.01
Thallium	<0.01	<0.01	0.02	0.01
TOC	1300	3800	1800	1
Zinc	67	120	200	0.01